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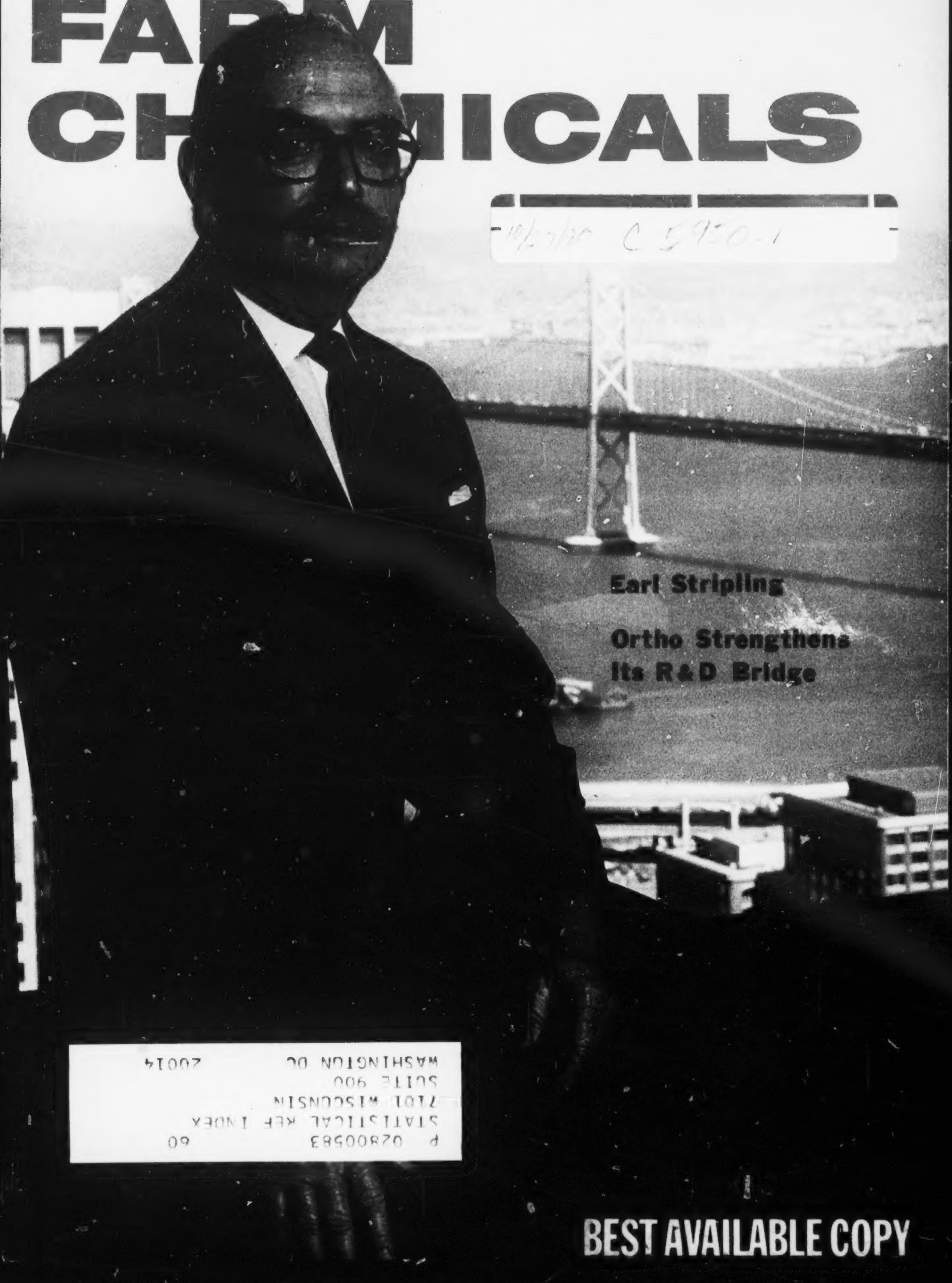

Earl Stripling

Ortho Strengthens Its R&D Bridge

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BPA MEMBER BUSINESS PUBLICATIONS AUDIT

The national business magazine for the fertilizer and pesticide industries, FARM CHEMICALS serves primarily manufacturers, formulators, mixers, dealers, and commercial applicators of fertilizers and pesticides, reaching those persons responsible for management, marketing, and production. Subscription rates are: in the U.S., its possessions; $16.00; in other countries, $20.00. Established in 1894 as THE AMERICAN FERTILIZER and incorporating CROPLIFE and AG CHEM & COMMERCIAL FERTILIZER.

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The Cover Story

Earl L. Stripling, Jr. is general manager of Chevron Chemical's Ortho Agricultural Chemicals Division. A veteran pesticide man, he looks to the future with enthusiasm, based on Ortho's current product line and new products to come. There is a big push being made in research at Ortho as the company makes a strong commitment to continue its position in U.S. and world markets. For the full story see page 13.

Global Agriculture Year 2000 A Strategic Analysis

This article doesn't give any predictions but it will help you in developing your own forecasts and strategy.

In preparation for the recent establishment of the MSD AGVET Division by Merck & Co., Inc., two task force studies were commissioned and carried out over the past four years. Central to the study on agrochemicals was a strategic analysis of global plant agriculture, whose objective was to develop an envelope of Year 2000 global agriculture scenarios from which plausible outcomes could be selected and studied. No predictions were attempted.

Because of the importance and character of the forces for change shown below, single-minded preoccupation with the problems of the agricultural production system to the exclusion of political, social, and economic effects is no longer possible. Ironically, since many past agricultural problems were addressed during the period when energy intensive agriculture and a lower level of consumer and environmental awareness prevailed, solutions to these problems may often be questionable by today's standards—
Stewart Stearns

By STEWART G. STEARNS

BUSINESS and agriculture have entered a period of unprecedented change which is forcing alterations in the methodology by which we seek to view the future. As John McHale puts it, "We have had more radical transformations of the human condition in the past 100 years than may have occurred in all recorded history—indeed most of this change has occurred in the last 50 years."

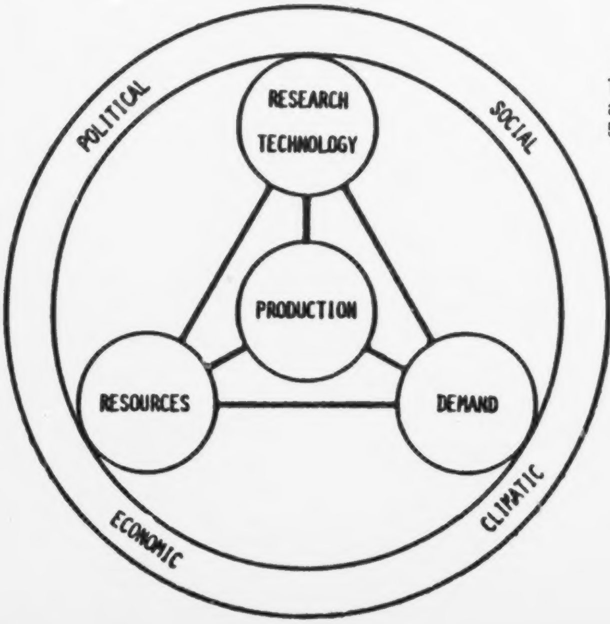
A basic factor is the accelerating growth of the world population. Between now and the year 2000, it will increase by 50% to 6 billion people. Although population increase is a powerful engine for agricultural growth, such inexorable growth produces political instability, a widening gap between developed and developing countries and, finally, intolerable demands on the world's capital and material resources. World population as well as the consumption of many ores and raw materials is now growing at an exponential rate.

The increase in our rate of travel speed (Figure 1) has facilitated the interdependence of society, the communication of ideas, the transport of man's goods and agricultural products, and even the exploration of space.

The increase in our ability to store and process information has been accompanied by a decrease in the time required to process data. Herman Kahn and his colleagues at the Hudson Institute forecast that by the year 2000 computer operating speeds will increase by factors of 10 to 1000 while storage capacity will increase by factors of 100,000 and upwards. The current trend toward faster, smaller, and cheaper computers and microprocessors has great implications for agriculture and agrometeorology in particular.

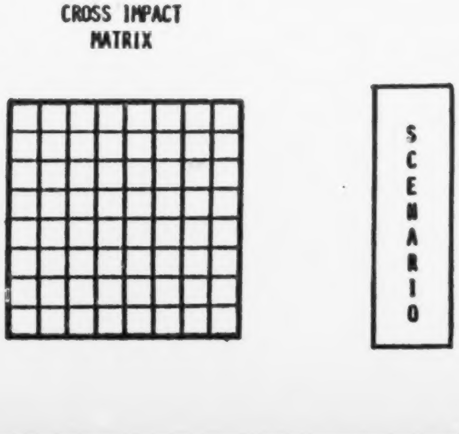
Man and his weapons have historically had powerful effects in the political arena. As a force for change, weaponry is becoming increasingly

GLOBAL AGRICULTURAL SYSTEM



PLAN FOR GLOBAL AGROCHEMICAL STUDY

The agrochemical study was carried out by a five-member task force over a period of two years and involved 10 consultants, 75 university visits, 50 field visits, and a review of over 500 literature references.



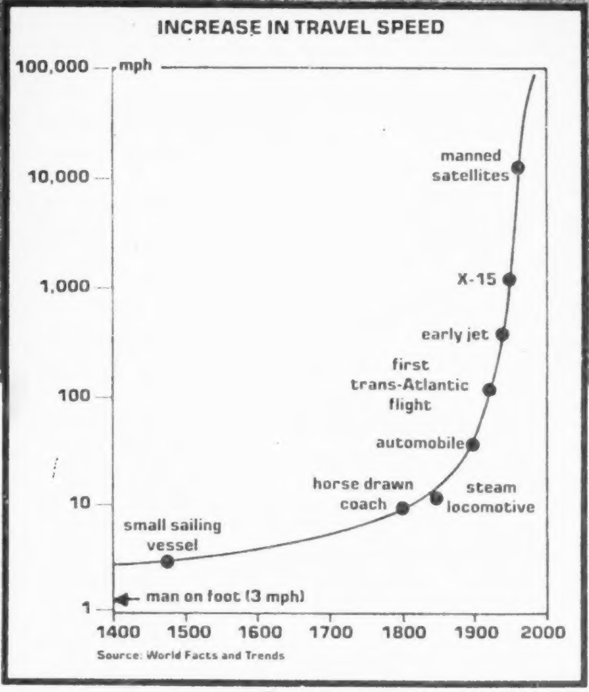


Figure 1

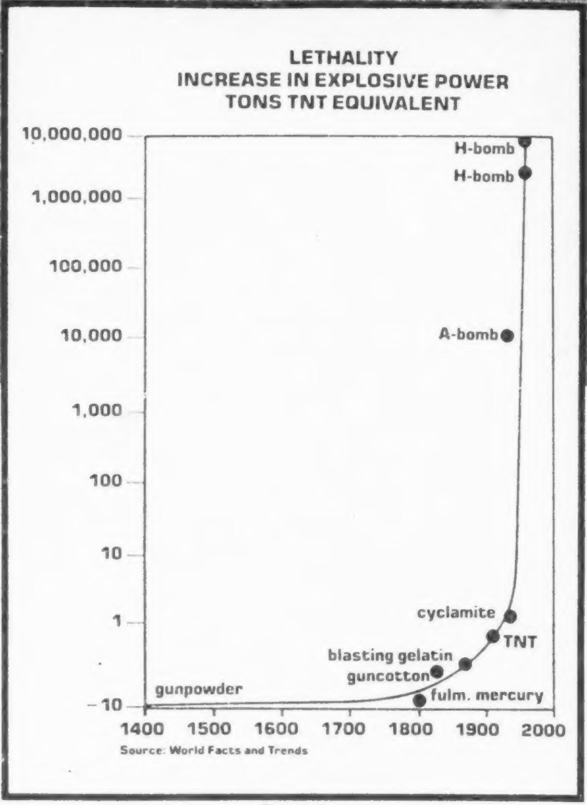


Figure 2

leveraged particularly as new nations join the "nuclear club." As the amount of energy at man's immediate command has increased, so has the lethality of his weapons (Figure 2).

Increases in the speeds of communication, transportation, and data processing and storage are narrowing the gap between scientific discovery, development, and large-scale application (Figure 3).

The time interval for adoption of new technology is similarly diminishing with the result that less time is afforded for critical assessment of social, political, and economic implications.

Some of the key elements in a plausible year 2000 scenario are as follows:

Demand

In the view of the task force, the year 2000 will see a world population of 6.0-6.25 billion with annual population increments of about 100 million per year, only 9% (about 9 million people) of which will be in developed countries.

Aggregate food demand in developed countries will be 50% higher than in 1978 while demand in developing countries will be 200% higher.

Aggregate food demand on a tonnage basis is expected to increase at 2.4–2.6% compounded growth rate to 2000. In the U.S., shifts in the age structure of the population will slow growth in the workforce, lower unemployment, and stimulate labor-saving technology, particularly in agriculture.

Physical resources will be generally adequate to sustain the population growth but capital demands by developing countries will strain free-world resources.

About 1.4 billion hectares of land are currently classed as arable. A further 1.7 billion hectares of land are potentially arable; however, the cost of development is estimated at $2.8 trillion. Land losses and degradation pose serious problems for world agriculture.

Energy will continue to be a rate-limiting factor with respect to the economy, relieved to some extent by new resource discoveries, new technology, and the use of agricultural crops or wastes directly or indirectly as energy sources.

Fertilizer and grain drying are two of the most important energy based agricultural inputs. The use of energy by agriculture as a percent of national requirements is low—less than 3% in the U.S. Consumption by the food chain represents over 16%. Economies in fertilizer timing and placement and use of solar drying for grain are the most obvious targets for agriculture.

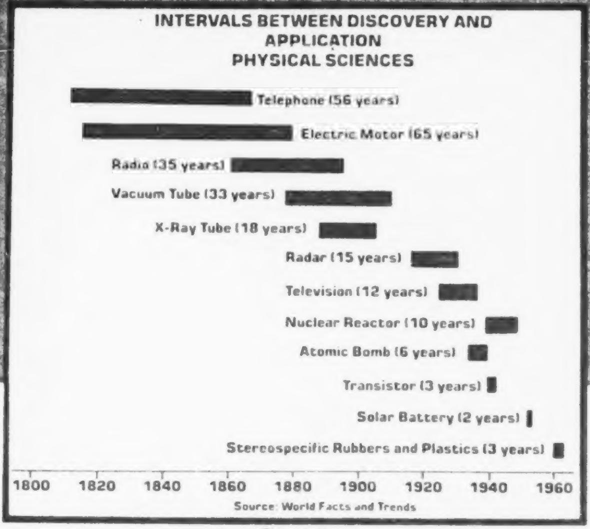
The costs of fertilizer, probably the most important limiting factor in agriculture, will continue to rise, reflecting higher natural gas prices, while the center of gravity of the world fertilizer industry will migrate from the U.S. to OPEC countries because of natural gas availability.

Production

The two most important elements from the point of view of this study are yields and losses. In the developed world, production increases for such crops as corn, wheat, rice, potatoes, and sugarcane have been attained largely through yield increases. There is still, however, a wide margin between average and record yields which differ by as much as a factor of 3–8, while theoretical yields are even higher. *A 10% increase in yield for the top 19 crops is valued at over $30 billion.*

The costs of inputs and the rising value of land make yield-improving and loss-averting technologies of increased value. For the 19 major food crops, losses from insects, weeds, and diseases are estimated to cause $150 billion in lost production, of which $50 billion is caused by disease.

Developing countries will realize production increases largely by land-utilizing technology plus fertilizer and high yielding hybrids. Developed



Source: World Facts and Trends

Figure 3

BENEFITS AND RETURNS FROM TECHNOLOGY AND SCIENCE ORIENTED RESEARCH U.S. 1868 — 1971

Subject	Annual Max Benefit $1,000 Inv.	Rate return
	1868 — 1926	
All Ag. Research	$12,500	65%
	1927 — 1950	
Ag. Research		
Tech. - Oriented	$11,400	95%
Sci - Oriented	$53,000	110%
	1948 — 1971	
Ag. Research		
Tech. - Oriented	$12,000 - 21,000	95 - 130%
Sci - Oriented	$ 4,500	45%

Source: Science 205 1105 (1979)

countries will experience a yield plateau due to the depletion of 1940-type technology.

Research/Technology

Because of the decline in support for basic agricultural research, the agricultural technologies of the 1940s—chemical fertilizer, pesticides, and plant breeding, which have led to the impressive production increases in developed countries—have spent their force and have not been replaced by new discoveries. Yields of major crops in many developed countries have plateaued, and new basic research is needed to move off the yield plateau.

In spite of the decreasing support for basic agricultural research in the U.S. and elsewhere in recent years, a number of scientific developments have occurred which could have profound effects on efforts to prevent crop losses and to move upward from the present yield plateaus. These include advances in such areas as genetics, photosynthesis, improved nitrogen fixation by plants, plant cell culture, and non-conventional technology for plant breeding, including recombinant DNA methodology.

It is ironic that a system of public research such as agriculture continues to be undervalued. As Evenson, Waggoner, and Rutan state in a recent issue of *Science*, "Despite annual returns on the order of 50%, which an economist would call clear evidence of underinvestment, investment in agricultural research remains static." (Figure 4)

As a result of societal and in turn regulatory pressures, governments are increasingly intervening in the agricultural field through controls over land, water, and pesticide use, and in the agricultural chemical field through increasingly rigorous environmental requirements. These threaten the existence of a number of pesticides and increase the cost, time, and risks of new product discovery and development. For example, it now requires approximately 110 months from inception to full registration for a pesticide under existing U.S. policies.

A report in 1979 by a U.S. Senate subcommittee concludes that worldwide subsidies and protective devices insulate world agricultural export prices from movements in exchange rates. Devaluation of the dollar negatively affects export volume and reduces returns to growers. The U.S. cannot assume the continuation of its predominant position in world agricultural markets. U.S. soybean producers, for example, face competition from Argentina and Brazil as well as from palm oil and related oil seeds. The same goes for cotton, and Brazil has now replaced the U.S. as the world's leading exporter of concentrated orange juice.

Slowing economic growth in developed countries, particularly Western Europe, will lead to increasing protectionism and decreased trading prospects. Latin America can move past Europe as a trading partner. The U.S., whose exports are currently 6.4% of GNP vs. 12–15% for Western Europe and Japan, will increase to an estimated 7.5% GNP; but its share of world exports will fall from 13% to 8% under pressure from rapidly industrializing lesser developed countries.

Agricultural products from the U.S. will, however, continue to be in great demand, but the U.S. position cannot be taken for granted.

Social pressures on food prices are high, and the grower is squeezed by rising costs of inputs and downward pressure on prices. This is causing grower unrest.

Economic

Rising costs of agricultural inputs and land values on the one hand and downward pressures on food prices on the other will lead to increasing grower unrest and militancy as well as the retirement of less efficient farmers.

It is startling to find that in many developed countries half or more of farm income is derived off-farm. Thus the marginal farm is being subsidized.

The rising value of farmland and the cost of acquiring new land is swelling farm debt, particularly in the U.S.

The capital requirements for farming are rapidly putting farming beyond the reach of the small farmer and new entrant.

Climate

Over the next 25 years northern hemispheric weather is expected to become increasingly variable which, together with a further cooling trend, will affect yields.

Since 1880 and until 1940, the average northern hemisphere temperature increased by .6°C. This period was extremely favorable for world and particularly U.S. agriculture. Since 1940 temperature has begun to fall, and there are strong indications of a return to the variable and unfavorable climate of the late 1800s.

The effects of these changes on yields are already evident in the U.K. and Canada where harvests are now occurring 7–9 days earlier than they were in the '40s. Wetter springs prevent the entry of equipment into fields, while earlier falls shorten the growing season. **FC**

Dr. Stearns is manager of strategic research for Merck & Co., Inc. Rahway, NJ.

For Details Circle No. 161 on Postcard

Illuminating Some Obfuscation About Pesticide Safety

Obfuscate: To darken by or as by depriving of light; to render obscure; to deprive of mental clearness; confuse; bewilder. **That's what some of the environmentalists have been doing when it comes to facts and figures on pesticides and safety.**

By KEITH C. BARRONS

OBFUSCATE—to confuse or perplex. So sayeth my dictionary. The word has not been a part of my vocabulary, but it seems to best describe the careless or purposeful way data of questionable validity is sometimes thrown around, even by university professors with presumed dedication to the truth. I hope to throw light on some recent obfuscation of the subject of pesticide safety.

Not long ago I had occasion to review data on the incidence of lethal episodes in the U.S. in the category "accidental poisonings by pesticides, fertilizers or plant foods," as recorded since 1968 by the National Center for Health Statistics. Their numbers reflect mainly accidental deaths and do not include deaths reported as suicides or homicides. The Center's tabulation of mortalities in this category as published in *Vital Statistics of the United States* is as follows:

1968—72
1969—56
1970—44
1971—43
1972—38
1973—32
1974—35
1975—30
1976—31
1977—34

The U.S. Environmental Protection Agency (EPA) has made estimates of the deaths associated with pesticide exposure (accidental plus intentional) by projection from data recorded by representative hospitals in different regions of the country. Relatively few of the observed episodes in this study were occupationally related. The estimated average number of mortalities attributable to pesticides for 1971 through 1976 (the years for which the statistical projections have been completed) is 53.

Considering that this number includes suicides and homicides while the average of 35 recorded by the Center for Health Statistics for the same years (1971–76) involves only accidents, the two sets of data appear in sufficient agreement to justify confidence in their validity.

Then I read on page 248 of Dr. Samuel Epstein's book, *The Politics of Cancer*,[1] ". . . . approximately 200 people estimated by EPA die annually from pesticide poisoning . . . ." How come data sent me by EPA averaged 53 while Epstein attributed the number 200 to the same source? I will risk possible misuse of the term to say I was badly *obfuscated*.

Although Epstein did not document his data beyond attributing it to EPA, he appeared to be quoting David Pimentel. Then in a new book of which Pimentel is co-author[2] I found the statement, "The total estimated mortality from pesticides is about 200 per year (EPA 1976)." Turning to the book's page of references I found that the EPA publication cited[1] was precisely the one I had used, along with subsequent data sent me by EPA,[3] for the derivation of the average of 53 lethal incidents for the years 1971–1976. A further study of these EPA reports confirmed that neither the data nor the accompanying discussions said anything about 200 mortalities per year. I was still *obfuscated*.

Possibly the 200 figure of Pimentel (as apparently quoted by Epstein) came from Table 101 of the 1976 EPA document.[1] This table summarized the projected lethal incidents for the entire period covered by that report—a total of 200 over three years. This is an average of approximately 67 per year. The lower average of 53 for the total span of these EPA records as referred to in the above paragraph reflects a marked reduction for the last three years that data has been made available, 1974–1976.[4]

In the literature review on page 1 of the 1976 EPA publication,[1] I did find the following statement: "It has been estimated that mortality resulting from pesticide intoxication approaches one death per million population annually." This carried a reference to a 1964 paper by Dr. Wayland J. Hayes, Jr.,[5] now of Vanderbilt University and author of the book, *The Toxicology of Pesticides*.

The literature review in the EPA document was obviously intended to give a comparison of mortalities in earlier years with more recent experience as set forth by the data contained therein. Possibly the 200 figure of Pimentel and Epstein came from this estimate, considering that U.S. population had passed the 200 million mark when they did their writing. But note the 1964 date on the paper by Hayes in which this statement appeared.

Dr. Hayes and his colleagues have performed a valuable service by critically analyzing available information on mortalities, including a review of death certificates for certain years. In table 11 of the latest report of their findings,[6] they present the number of

About the Author

Dr. Keith C. Barrons' career spans both industry and research. He has been a plant breeder for Burpee Seed Co., member of the faculty of Auburn University and Michigan State University, and an agricultural technologist with Dow Chemical Co. He is co-developer of the Great Lakes lettuce variety and has authored more than 100 papers and patents relating to vegetable crop breeding and chemical weed control. His accomplishments also include discovery of dalapon herbicide.

In 1975 Dr. Barrons published the book *The Food in Your Future—Steps to Abundance*. Written for the layman, it offers valuable insight into what is required to ensure an abundance of reasonably priced food.

This article is excerpted from his forthcoming new book, *Are Pesticides Really Necessary? A Look At Both Sides of the Coin*, to be published in 1981 by Regnery/Gateway, Inc., Chicago.

deaths associated with pesticide poisoning for all those years in which they carried out detailed studies as follows:

1956—152
1961—111
1969— 87
1973— 61
1974— 52

As in the EPA study they found most lethal episodes to be non-occupational in nature. Accidents included drinking a pesticide kept in unlabeled soft drink or liquor bottles; storages accessible to children or the incompetent; grossly careless use of fumigants or poison baits; allowing children to play around a loaded sprayer where valves could be opened. According to the death certificates reviewed, several victims were intoxicated with alcohol when the careless pesticide exposure occurred.

The reference to one mortality per million in Dr. Hayes' 1964 paper was a valid estimate for years prior to that writing. However, a review of his more recent data above, together with that from EPA and the National Center for Health Statistics, should convince anyone that Pimentel's and Epstein's 200 figure could grossly mislead the public as to recent experience.

It is inconceivable that neither of these authors had at hand the publication by Hayes and Vaughan[6] which appeared in a respected journal. They surely must have had the entire 300-page 1976 EPA report[3] and not just the three pages devoted to a literature review or Table 101 which was misread. One wonders why they did not refer to data from the National Center for Health Statistics as published in *Vital Statistics of the United States*, a reference book found in every university library.

Attributing data to EPA that erred by a factor of three or passing off a 20-year-old estimate to the unsuspecting public while ignoring an abundance of more recent data that documents a marked reduction in mortalities is hardly the kind of scholarship expected of university professors.

A glance at the accompanying table, which presents U.S. lethal poisoning data for various classes of substances for the years 1975–1977, as collected by the Center for Health Statistics (the last three years for which figures have been published at this writing) will indicate their relative importance as causes of mortality.

Records of acute poisoning cases admitted to a hospital for treatment are believed by EPA[3] to "provide the best potential for a reliable data source." That agency's estimates of U.S hospital admissions resulting from pesticide poisoning for the years 1974–1976, the last three years for which their statistical projections have been completed, are presented in the accompanying table.

Lethal Poisonings in U.S. (Various Substances)
Source: Center for Health Statistics

Type of Poisoning	Number of Deaths		
	1975	1976	1977
Total lethal poisonings	6271	5730	4970
Gases and vapors	1577	1569	1596
Drugs and medicaments	3132	2839	2214
Other solids and liquids (excluding agricultural chemicals)	1532	1291	1126
Pesticides and Plant Foods	30	31	34

Estimated Hospital Admissions from Pesticide Poisonings
Source: Environmental Protection Agency

Year	Occupational	Non-Occupational (including unclassified)	Intentional	Total
1974	686	1733	535	2954
1975	985	1830	499	3314
1976	685	1879	446	3010

All statistics on pesticide-related mortality and morbidity indicate that children account for a distressingly high proportion of victims. According to EPA estimates nearly 40% of hospital admissions in the non-occupational column in the accompanying table were under five years of age. Let us hope that future statistics will show a safety benefit from the elimination of the more toxic materials from home and garden use. Let us further hope that with our current drive toward safer application procedures, secure storage, more careful container disposal, and precautions regarding re-entry time, the occupational column will show a downward trend.

In recent years fear of cancer has dominated concerns for the safety of all classes of substances including pesticides. The public needs reminding that:

1. No instance of human cancer associated with the approved use of any pesticide has even been documented.
2. For more than two decades all prospective new pesticides have been evaluated for carcinogenicity in laboratory animals, and only those found to be free from tumor-inducing effects (and otherwise safe from the toxicological standpoint) have been commercialized.
3. A number of older pesticidal chemicals found to have a carcinogenic potential when retested on laboratory animals have been removed from the market.

The public should also be reminded that older pesticides that have been banned or uses restricted because of carcinogenicity caused tumors in laboratory animals only at doses considerably exaggerated over likely human exposure. Even though one subscribes to the philosophy of the Delaney Clause and believes that response to relatively high doses in animals is evidence that traces of a substance may cause an occasional cancer in humans he must recognize that the odds are very, very slight. Those who believe that the body's natural defense mechanisms prevent traces of substances from inducing cancer will have no concern. With respect to non-carcinogenic risks, the public needs to be reminded of the very wide margin for safety that regulatory authorities provide when establishing permissible tolerances in foods. **FC**

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THE COVER STORY

When NAAA and NFSA get together for their conventions this December, there will be a wealth of idea-sharing going on. Starting on page 13, FC looks at some of those ideas on improving application techniques that will be "talked-about" and "looked-at" during the convention, and perhaps incorporated into many applicator's operation over the next few years.

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MEMBER BUSINESS PUBLICATIONS AUDIT

The national business magazine for the fertilizer and pesticide industries, FARM CHEMICALS serves primarily manufacturers, formulators, mixers, dealers, and commercial applicators of fertilizers and pesticides, reaching those persons responsible for management, marketing, and production. Subscription rates are: in the U.S., its possessions; $16.00; in other countries, $20.00. Established in 1894 as THE AMERICAN FERTILIZER and incorporating CROPLIFE and AG CHEM & COMMERCIAL FERTILIZER.

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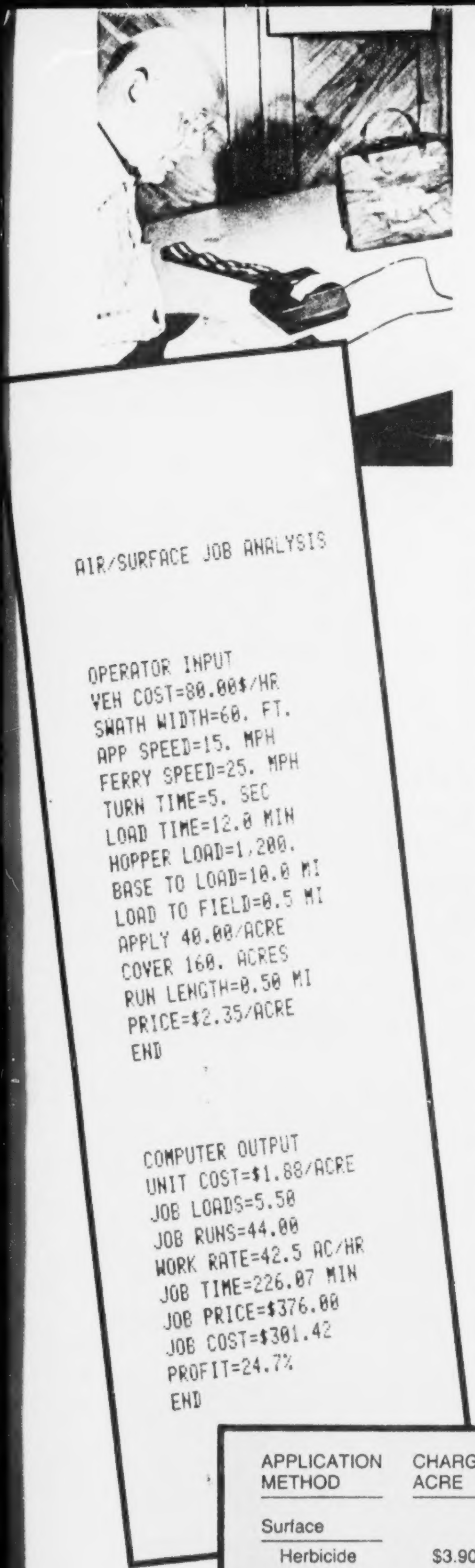
Quit the Guessing Game!

With programmable calculators or pocket computers you can easily—and accurately—figure the price, cost, and profit on each application you make.

By GEORGE S. SANDERS



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AIR/SURFACE JOB ANALYSIS

OPERATOR INPUT
VEH COST=80.00$/HR
SWATH WIDTH=60. FT.
APP SPEED=15. MPH
FERRY SPEED=25. MPH
TURN TIME=5. SEC
LOAD TIME=12.0 MIN
HOPPER LOAD=1,200.
BASE TO LOAD=10.0 MI
LOAD TO FIELD=0.5 MI
APPLY 40.00/ACRE
COVER 160. ACRES
RUN LENGTH=0.50 MI
PRICE=$2.35/ACRE
END

COMPUTER OUTPUT
UNIT COST=$1.88/ACRE
JOB LOADS=5.50
JOB RUNS=44.00
WORK RATE=42.5 AC/HR
JOB TIME=226.07 MIN
JOB PRICE=$376.00
JOB COST=$301.42
PROFIT=24.7%
END
```

IN August FARM CHEMICALS published a survey of custom applicators and the results reflected some "gut feeling" ways as to how some applicators set their prices for the services they perform for the farmer. More than one-third admitted that their charges were based on what their competitors were charging. Without identifying application rate or any other factor, the results produced the average data shown below.

Not bad in terms of average profit based on costs for the custom applicator's services determined after he completed his season and at the year's end. But how can the custom applicator predetermine the price, cost, and profit for each application he is called upon to quote and service? Nowadays, it's "more of a snap" to compute than most applicators realize.

Programmable calculators, or pocket computers as they are sometimes called, with specialized programs for custom applicators are now available that *automatically* compute price, costs, and profit and much more without requiring any knowledge of the complicated electronic computing methods fed into the computer by magnetic cards. All the custom applicator has to do is turn the machine on and input numbers that are applicable to the job under evaluation. When this is completed, a mere tap on the compute key is all that is required to display or print out his inputs and produce the job answers.

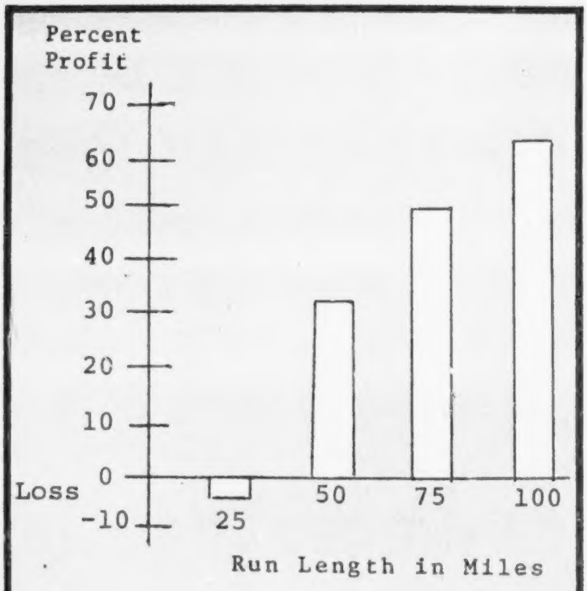
APPLICATION METHOD	CHARGE/ ACRE	COST/ ACRE	PROFIT/ ACRE	% PROFIT
Surface				
Herbicide	$3.90	$3.17	$ .73	23.0
Insecticide	$3.88	$3.25	$ .63	19.4
Air				
Herbicide	$3.30	$2.29	$1.01	44.1
Insecticide	$3.31	$2.44	$ .87	35.7

One such pocket computer was introduced by Agrinautics nearly a year ago to the airborne custom applicator. Since then, its program has been revised to fit both the air and surface custom applicator alike.

Each job the custom applicator is called upon to do or quote has different characteristics than others and these differences have a substantial impact on the job profit that can be generated. It's not hard to visualize that the cost per hour of the equipment systems used on the job may vary widely from applicator to applicator and this, combined with other widely varying job factors, determines the time and cost for performing the custom applicator service. However, what was nearly impossible to determine heretofore is now a reality. Such things as profit impact caused by operational factors such as field distance, field size, length of run, application rate in relation to the vehicle load, speed and swath width, etc. are quickly and automatically calculated by the Air/Surface Job Analysis pocket computer offered by Agrinautics.

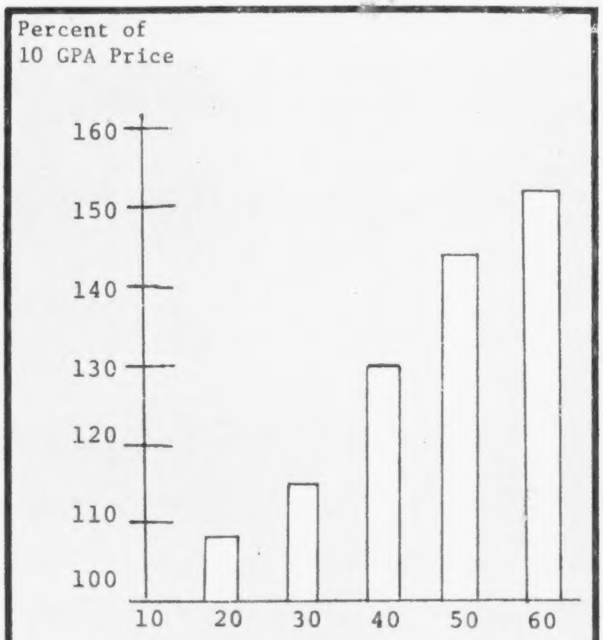
To reveal all the factors involved in any operation, refer to the accompanying computer printout. There are thirteen factors (parameters) that inter-relate with each other to derive job answers. In the automatic computation by the computer system, eight answers are generated, each of which are important in some way to the custom applicator. In addition, the computer signals the applicator when the last swath is partial and when the job profit is negative (is a loss). The former may be very important to the applicator in selecting an optimum swath for the job and the latter requires no further amplification.

Remember, the computer user only has to punch in the numbers and the computer automatically prints out the parameter notations, together with the number entered by the user. A keyboard overlay guides the user to input the numbers for successive fac-



Profit versus run length at 3 GPA and $2.00/acre with aerial application

RUN LENGTH	% PROFIT (LOSS)
.25	- 3.5
.50	32.4
.75	50.1
1.00	61.6



Percent of price increase for application rates of 10 GPA to maintain a 25% profit for ground spraying.

tors and directs him by color coded lines to keys for starting the computations and displaying and printing the answers. The custom applicator need only hit numbers for any factor or factors he wants revised and have the computer generate new answers under the changed conditions. The user, for example, may quickly evaluate the impact on his profit for ¼, ½ or 1 mile runs, leaving all other factors the same.

The same pocket computer accepts preprogrammed magnetic cards on a host of other problem-solving requirements designed for custom applicators and small business operations. Fertilizer batch mixing and blending, pesticide mixing, employee payroll computations, employee year-ending withholding reports, etc. are just a few of the available programs from other sources that can be entered into your programmable calculator.

Most important to the ag air or surface operator, there are programs available to determine cost of operating any piece of equipment or system of equipment. However, for the purposes of this evaluation, the cost per hour of any system of equipment can be determined by totaling your entire business expenses, including direct costs, taxes, and insurance, etc., and dividing it by the number of hours of operation of those systems.

In the case of a dual business where chemicals are also sold, the businessman may allocate expenses on the same percentage as their respective sales volume or some other criteria. For example, if chemical sales are $600,000 and application sales are $400,000, then 40% of the business expenses may be allocable to the application business and 60% to the chemical sales business. This expense allocation or some other value determined by the operator may then be divided by the number of applicator system hours experienced during the same accounting period as were the expenses.

These estimates of expenses and thus cost per hour of operation of his equipment provide a good number to use in the computer analysis. However, in the final evaluation, the answers provided by the computer are more accurate than anything most operators have had to date and this in itself gives the manager substantially better information on which to make his daily operating and pricing decisions.

For those who cannot provide the cost per hour of operation of their equipment, not all is lost. You still can work the system backward by establishing your profit goal desired or profit history for average conditions in your area and computing the answers with varying cost/hour values until your profit goal is computed in the answers. That cost per hour, which obtains your profit goal, will be the cost per hour you must experience to generate the desired profit. Of course, a lesser business cost per hour will increase your profit.

Still further, custom applicators may benefit from the use of small programmable calculators by comparing varying job conditions, one at a time, such as base to field distance, swath width, application rate, field size, or any other parameter value. The impact of varying any value of a given factor can be truly seen even though the cost/hour value is inaccurate as long as it is maintained throughout the comparisons. **FC**

Mr. Sanders is general manager of Agrinautics, Inc., Las Vegas, NV.

DECEMBER • 1980

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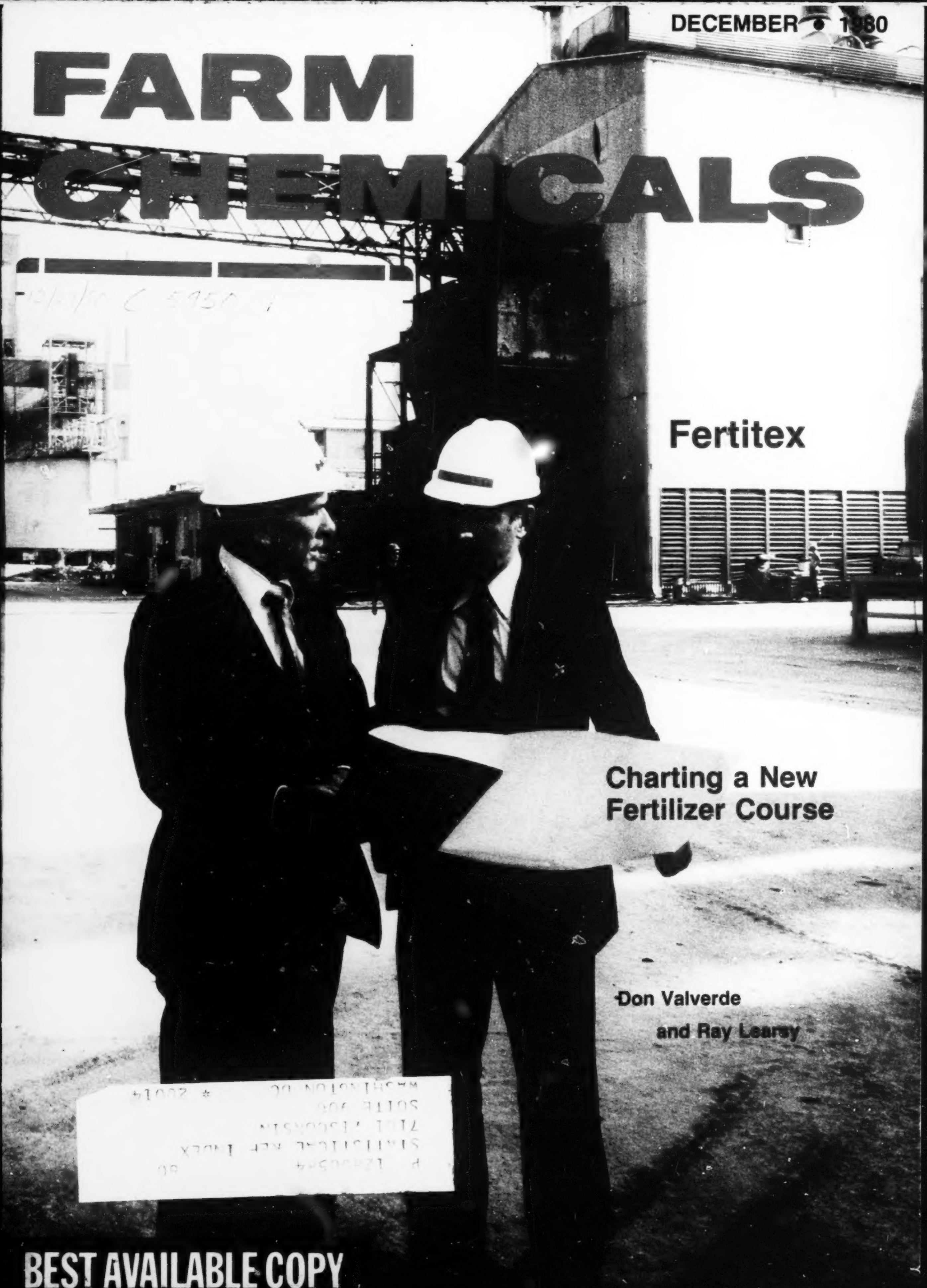

Fertitex

Charting a New Fertilizer Course

Don Valverde
and Ray Learsy

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Vol. 143 No. 12 December 1980

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COVER STORY

From a "touch and go" beginning in 1977, the Fertilizer Company of Texas (Fertitex) has since more than tripled its sales. The reason, according to founders Ray Learsy and Don Valverde, is that "we will do things other companies just won't do" for fertilizer customers. For the complete story on this "fertilizer supermarket", turn to page 13.

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Spray or Mow . . .
Which Way to Go?

There are over 23 million acres of highway right of way in the U.S. In response to an FC survey, 36 states tell how they manage their roadsides and how much it costs.

ROADSIDE weeds—just how big is the market for chemical control of this problem? How do various states take care of their roadsides, and how many acres and miles are involved? To find the answers FC surveyed the 50 states recently. Of the 36 states that responded, 32 reported spending the total of $61,609,940 annually on eliminating weed problems along their highways. A total of 1,137,945 acres and 97,799 miles were being cared for in 33 of the states.

In addition, 18 of the major chemical companies responded to a companion survey by enumerating the products they market for roadside care as well as some new products that will be available.

Richard W. Gray, Jr., agronomist with Nebraska's department of roads, emphasizes, "Not all weeds are bad—only the plants out of place. Weeds pioneer some soil where grass would fail and protect the soil from erosion until a permanent vegetation is established."

The weeds that are "out of place" are controlled through a variety of methods, usually mechanical and/or chemical. The theories about how to manage weeds range to both extremes, although most states combine the two methods and some add cultural and biological means.

The area considered as right of way in the U. S. (for highways, railroads, pipelines, and electric utilities)

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amounts to over 34.2 million acres, roughly the size of Arkansas. Of the total, 23.3 million acres belong to highways, 5.1 million to electric utilities, 3.4 million to pipelines, and 2.4 million to railroads. Over half, 18.2 million acres or an area a little larger than West Virginia, are in potential danger of developing woody vegetation problems.

For railroads the area requiring care usually averages 25 feet from both sides of the track, with about 9 feet between track centers in the case of double track. The right of way for a highway may be as wide as 300 feet on the interstate systems, narrowing down in and near cities and towns. To convert this into acreage, as some companies and states prefer, consider a swath 8 feet wide by a mile long as equivalent to an acre.

"That's a lot of weeds to worry about, and we can't keep up by just mowing," points out a maintenance director from the U. S. Department of Transportation. "Some areas of the country have real problems. Trees actually spring up alongside the road and heave the concrete. We can't always have the crews out there as often as we should to keep the vegetation chopped down."

As far as the departments responsible for state-controlled roadsides are concerned, opinions about what is best to do vary. In Kansas "extensive use of chemicals for weed control has never been a practice," and noxious weeds are treated on the county rather than on the state level. Conversely, in Kentucky the feeling is that "mechanical mowing is not considered to be an effective means of controlling weeds," and *only* chemical methods are employed.

Over the long haul chemical means are far more economical. Whether the state departments of highways and or transportation do the actual work themselves, as most do, or place the jobs on bid to independent contractors, cost of mechanical control is considerable.

"Data collected by Texas A & M and our company indicates approximately 30% savings by using chemicals for Bermuda release compared to mechanical control, and the results are better," says William B. Parker, product development manager for Crystal Chemical Co. (Parker estimates his company's products are used on 500,000 acres of railroad and roadway right of way each year, either alone or in combination with a soil residual herbicide.)

A sales representative for Vertac Chemical Corp., William Fowlkes, Jr. points out, "Mechanical control estimates range as high as 10 times the cost of control with 2,4,5-T."

William Bertges, product manager-marketing at Velsicol Chemical Co., reports, "For broadleaf weed and brush control, our products cost $7.50 to $50 per acre, depending upon target species, application equipment, application techniques, and timing of application, versus mechanical control from $20 to $50 per acre."

Looking to the future, several of the companies and states feel that any significant changes in methods of control may be away from the lower cost chemical control unless the public is better informed on how chemicals are used safely in current programs.

Public Pressure?

The U. S. Department of Transportation maintenance director admits that his department used to spray 2,4-D, which successfully controlled problems along the interstate highways, until "one lady complained that we were spoiling her environment, and we were told to stop."

Some efforts are being made by highway and transportation department officials to inform officials and politicians about the cheaper cost of chemicals, but not all programs are aimed at the general public.

T. L. Cain, maintenance engineer with the Alabama Highway Department, explains that complaints about spraying have been few, probably because his department has been able to "restrict brownout to a minimum and avoid claims due to drift damage." He adds that there is no formal program for public education, but they do take "before and after" photos and develop a cost analysis of mowing and herbicide treatments to illustrate comparative costs.

Iowa reports pressure "only in isolated areas," while Minnesota has experienced "some discussion on nonchemical methods but no real pressure."

Oregon reports some public pressure, "but nothing as bad as the forest industry is receiving," says agronomist Joe Hay of the department of transportation's highway division. He adds that under the circumstances a public information program would only draw more attention to the use of chemicals. Until the furor with the forest industry dies down, his department will direct its information to the governor and the legislature "so that pesticide use will not be restricted or eliminated." Several other states agree with this approach.

Because of some public pressure, New York state is "trying to restrict use of chemicals to those areas where we feel we really need to use them, for example, soil sterilant under guard rails," explains highway maintenance director George Russell.

North Carolina has been under pressure to discontinue use of "restricted use of 'newsworthy' chemicals like 2,4,5-T, Tordon, etc.," says E. F. Vernon, section engineer for landscape field services in the department of transportation's division of highways.

A booklet on pesticide safety written by the Maine Department of Transportation has been "very well received," says landscape architect Clyde Walton. The booklet, designed as an educational program for the layman to counteract adverse publicity the department's spray program had been receiving, explains what methods are used along the highways and why chemicals are essential.

A few other states report mild public reaction, usually against the use of phenoxy herbicides.

Pennsylvania and Idaho answer criticism on an individual basis through the use of statistics, and Illinois has "no real program" but emphasizes that "the control of noxious weeds is required by state law."

Virginia also uses the individual approach, meeting "with persons who object to spraying near their properties and pointing out the comparative cost and effectiveness of chemical versus mechanical control," explains R. L. Hundley, environmental quality engineer for the department of highways and transportation.

Director of the roadside services division of West Virginia's department of highways, Darrell L. Buttrick reports that his state is presently developing a "comprehensive vegetation control program." In the process, they have discovered that "public reaction to the use of brush control chemical application" is reduced when the public is convinced how safe chemicals are.

Outlook Steady to Good

Many of the chemical companies believe that their product sales for roadside use will continue at the present level. A few are more optimistic.

Elanco Co. and Monsanto Agricultural Products Co. feel that higher mowing costs due to increased labor and equipment costs will cause states to consider increasing chemical controls. Rhone-Poulenc Chemical Co. anticipates its sales will increase at least 2-4% for this reason.

Even if the total amount of area to be tended does not increase, the potential is there for chemical sales to increase a tremendous amount. The easiest, surest, most efficient way to control weeds, brush, and trees on all rights of way is chemical, most experts agree. The main problem seems to be how to convince the bureaucracy. FC

See page 29 and 30 for state-by-state listing of control methods and products.

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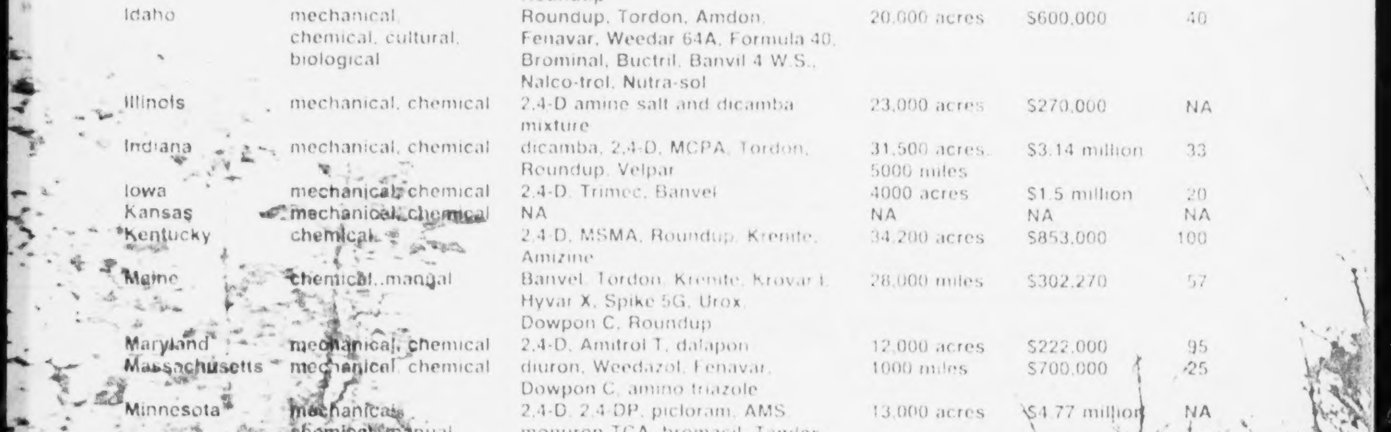
HOW STATES CONTROL ROADSIDE WEEDS



State	Control Methods	Chemicals	Area	Investment	% Chemical
Alabama	mechanical, chemical	MSMA, 2,4-D, Krenite, Tordon 101, Krovar I, Hyvar XL	85,000 acres	$4.5 million	22
Alaska	mechanical	none	250 acres	$35,000	0
Arizona	mechanical, chemical	Phytar 560, Surflan 75W, Rad-E-Cate, Ureabor, Roundup, Weedone, Krovar, Hyvar X, Spike, Primatol	3748 acres	$380,000	25
Arkansas	mechanical, chemical	MSMA, prometone, simazine, diuron, maleic hydrazide, Roundup, Krenite	90,000 acres	$4.5 million	13
California	mechanical, chemical, manual	princep, Karmex, Roundup, Krenite, diquat	39,879 miles	$5.5 million	50
Delaware	mechanical, chemical	2,4-D, princep, Surflan, Roundup, Krenite, Devrinol, Ronstar, Asulox	8974 acres	$478,000	12
Florida	mechanical, chemical, manual	2,4-D, dicamba, ammonium sulfamate, diquat, dalapon, Roundup, Asulox, Velpar	13,000 miles	NA	NA
Georgia	mechanical, chemical	MSMA, bromacil, paraquat, Roundup	447,500 acres	$4.8 million	9.5
Idaho	mechanical, chemical, cultural, biological	Roundup, Tordon, Amdon, Fenavar, Weedar 64A, Formula 40, Brominal, Buctril, Banvil 4 W.S., Nalco-trol, Nutra-sol	20,000 acres	$600,000	40
Illinois	mechanical, chemical	2,4-D amine salt and dicamba mixture	23,000 acres	$270,000	NA
Indiana	mechanical, chemical	dicamba, 2,4-D, MCPA, Tordon, Roundup, Velpar	31,500 acres, 5000 miles	$3.14 million	33
Iowa	mechanical, chemical	2,4-D, Trimec, Banvel	4000 acres	$1.5 million	20
Kansas	mechanical, chemical	NA	NA	NA	NA
Kentucky	chemical	2,4-D, MSMA, Roundup, Krenite, Amizine	34,200 acres	$853,000	100
Maine	chemical, manual	Banvel, Tordon, Krenite, Krovar I, Hyvar X, Spike 5G, Urox, Dowpon C, Roundup	28,000 miles	$302,270	57
Maryland	mechanical, chemical	2,4-D, Amitrol T, dalapon	12,000 acres	$222,000	95
Massachusetts	mechanical, chemical	diuron, Weedazol, Fenavar, Dowpon C, amino triazole	1000 miles	$700,000	25
Minnesota	mechanical, chemical, manual, cultural, biological	2,4-D, 2,4-DP, picloram, AMS, monuron TCA, bromacil, Tandex, simazine, diuron	13,000 acres	$4.77 million	NA
Mississippi	mechanical, chemical	Ureabor, Hyvar XL, Primatol 25-E, Banvel, Roundup, Velpar, Ammate X, Amizine, Lorox, Krenite, Maintain CF-125, MSMA	225,000 acres	$3 million	15
Missouri	mechanical, chemical	2,4-D, diquat, MSMA, Krenite, dalapon, Karmex, Banvel pellets, Dacthal, Spike, Velpar, Ammate	19,000 acres (chemical)	$7.5 million	[illegible]
Montana	mechanical, chemical	2,4-D, simazine, Roundup	9149 miles	$643,000	45
Nebraska	chemical, manual	2,4-D, Trimec, Banvel, Pramitol, Spike, Tordon, Phytar 560	1500 miles	$150,000	95
New Hampshire	mechanical	none except on experimental basis	4150 miles	$750,000	0
New York	mechanical, chemical	Weedone, amino triazole, simazine	20,000 miles	$1.4 million	15
North Carolina	mechanical, chemical, manual	2,4-D, dicamba, Garlon 3A, MCPP + 2,4-D amine, Roundup, simazine/Surflan tank mix, Treflan, Dowpon C, Spike, Pramitol, diuron	8000 acres, 2000 miles	$6 million	10 or less
Ohio	mechanical, chemical	2,4-D, Krenite, Tordon Beads	1000 miles	$3.74 million	13
Oklahoma	mechanical, chemical, biological	DSMA, MSMA, Roundup, AAtrex 4L, Spike, Surflan, Primatol, Velpar, Hyvar X, Banvel XP, Tordon	55,000 acres	$2.1 million	[illegible]
Oregon	mechanical, chemical, biological	Princep, Atratol, Karmex, Krovar, fenac, Embark, Trimec, amitrole, Casoron, 2,4-D, Weedone 170, Dowpon, Kerb, Roundup, Krenite, Tordon, Spike	18,300 acres	$605,000	95

(Continued on page 30)

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HOW STATES CONTROL ROADSIDE WEEDS (continued)

State	Control Methods	Chemicals	Area	Investment	% Chemical
Pennsylvania	mechanical, chemical, biological	2,4-D, picloram, Krenite, Banvel, Roundup, Brominal, Asulox, Weedone 170, Karmex, Princep 80 W, Telvar, Amizine, Velpar	20,000 acres	$2 million	50
South Dakota	mechanical, chemical	2,4-D, picloram, bromacil, monuron, prometon, Roundup	18,000 acres	$153,670	88.5
Utah	mechanical, chemical	atrazine, Amizol, Tordon, Igran, Banvel, Roundup, 2,4-D	20,000 acres	$230,000	NA
Vermont	chemical	Hyvar XL, Krenite	1500 miles	$39,000	40
Virginia	mechanical, chemical	2,4-D, dicamba, maleic hydrazide, Krenite, Roundup	NA	NA	NA
Wisconsin	mechanical, chemical	2,4-D, Banvel, Tordon Beads	11,500 miles	$100,000	NA
Wyoming	mechanical, chemical	2,4-D, Banvel, Hyvar XL, Pramitol, Tordon	3500 acres	$542,000	28

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[1] NA indicates that the information was not available at this time.

SOME PRODUCTS AVAILABLE FOR WEED CONTROL

Company	Products	New Products	Projected Sales[1]
American Cyanamid Co.	Amino Triazole Weedkiller 90, Cytrol Amitrole-T Liquid Weedkiller	NA[2]	Steady
Chevron Chemical Co.	Ortho Paraquat CL, Ortho Diquat 2, Chevron Industrial Weed & Grass Killer	Several new numbered compounds, one for grass and one for general use	Up
Ciba-Geigy Corp.	AAtrex, Princep, Pramitol	NA	About the same
Crystal Chemical Co.	Mesamate Concentrate, Mesamate 600, Broadside, Phytar 560	Working with other companies on new tank mixes	Expects great increase in all but railroad use
Diamond Shamrock Corp.	2,4-D, MSMA, dalapon	Will be investigating MCPP and 2,4-DP in certain markets	Stay the same; maybe slow decline
Dow Chemical U.S.A.	Tordon, Vertan, DMA-4	Garlon 3A registered in 1979—3 lb. active ingredient gallon amine formulation of triclopyo miscible in water	Up
Elanco Products Co.	Spike, Surflan 75W	New EPA clearances for Spike 80W in banded and spot gun applications have been granted; new tank mix labels expected soon for Spike	Up because of increased labor and equipment costs
Guth Corp.	Lithate 2,4-D	NA	NA
Hopkins Agricultural Chemical Co.	Urox	Dozer being introduced in 1980; looking for formulations that will work as basal treatments without use of oil as diluent	Up due to suspension of 2,4,5-T
Mobay Chemical Corp.	NA	Ustilan is in research stage for semi-total nonselective control	No significant change
Monsanto Agricultural Products Co.	Roundup	Working on tank mixtures that would provide seedling as well as initial control	Up due to higher mowing costs
Rhone-Poulenc Chemical Co.	Asulox, Buctril, 2,4-D, MCPA, Visko Rhap	Improved control programs with Asulox under development	Up 2–4%
Sandoz, Inc.	NA	Possibility of norflurazon having applications for industrial herbicide use either alone or in combinations	NA
Shell Chemical Co.	atrazine	NA	Probably up
Uniroyal Chemical Co.	Slo Gro	NA	Stay the same
Velsicol Chemical Corp.	Banvel, Brush Buster	Screening of total vegetation management chemicals is an ongoing project; several research projects show utility in this area	Same or slight decline
Vertac Chemical Corp.	Weed Rhap, Brush Rhap	NA	Same
Vineland Chemical Co., Inc.	monosodium acid methanearsonate, cacodylic acid	Continuing research	Up

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[1] Companies were asked in what direction they felt the sales of chemicals for weed control would go over the next three year period.

[2] NA indicates that information was not available at this time.

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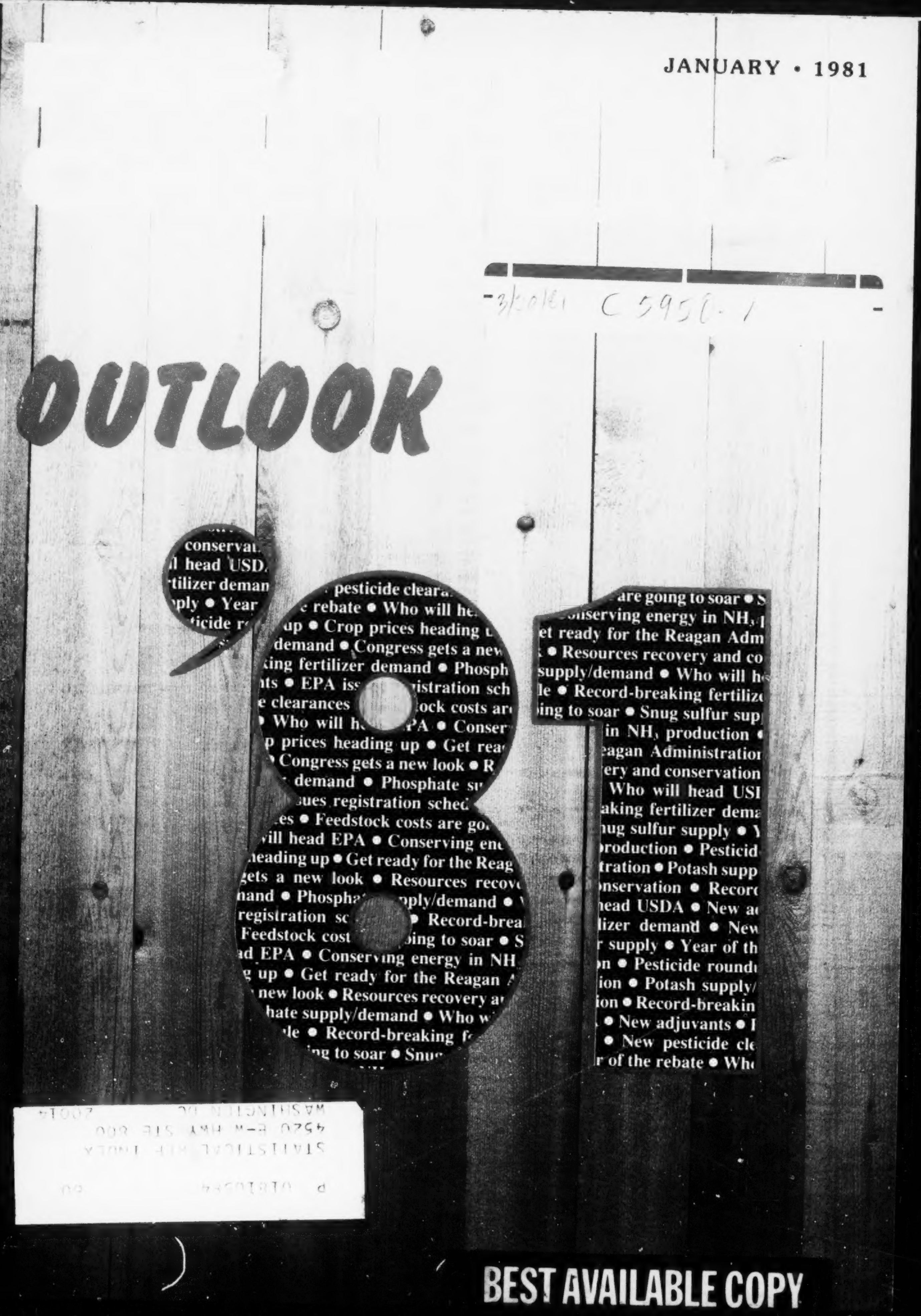
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142 Editorial: "1980—It Was a Very Strange Year"

THE COVER STORY

Outlook '81—that's the theme of this special issue, and the outlook for the most part is a good one. A record-breaking fertilizer year seems in the making, and TVA's John Douglas is advising manufacturers to "produce every ton you can." There's optimism in Washington about the new Secretary of Agriculture, John Block, who looks at agriculture as "the great American weapon." On the pesticide side, more than 300 products are featured in our annual Pesticide Roundup. Be certain to read "The Year of the Rebate" on page 36 for some pros and cons on current marketing strategies of some suppliers. As the editorial points out, "1980 was a very strange year." We look for 1981 to be different.

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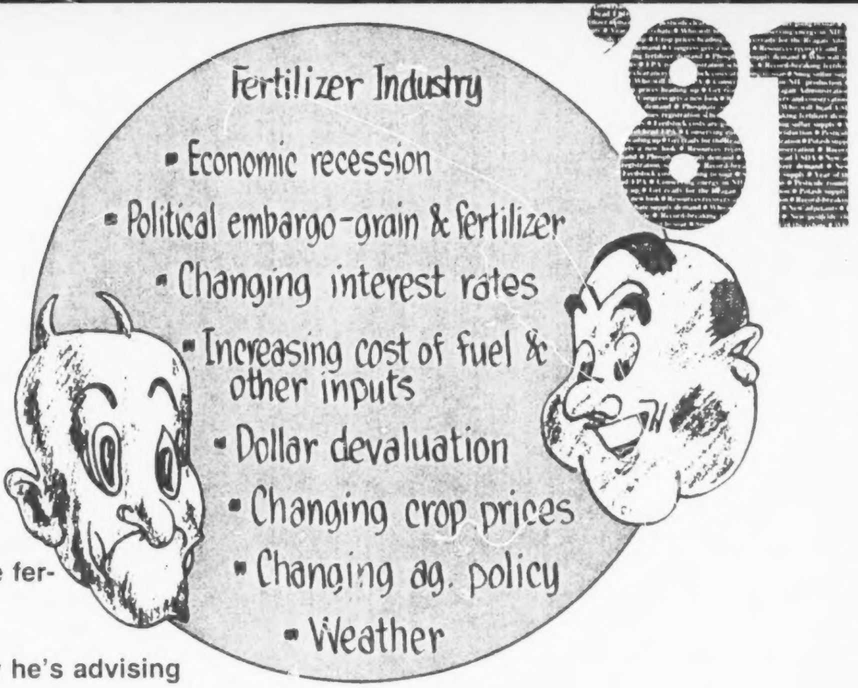


There's no denying John Douglas' optimism about the fertilizer market for '81. In this exclusive interview, the TVA economist tells why he's advising companies to

"Produce Every Ton You Can. It Will Be Used!"

Dr. Douglas, how is fertilizer demand shaping up?

This is going to be an exciting year. There are many things that foretell nothing but good for the U.S. farmer—and for the fertilizer industry.

The world is using more total grain than it produces. It is clear that we used more last year than we produced. For the coming year, if we use what could be expected, we will use appreciably more than we produced this past year. The marketing year ended in October with much smaller grain reserves than we had when we started—some 13% smaller. Total grain carryover during the current year is expected to drop an additional 20%.

U.S. *coarse* grain supplies will drop to 40% of what they were at the beginning of the marketing year. World coarse grain supplies will drop from about 90 million metric tons to a level of slightly above 55 million. Coarse grain inventory carryover will probably be lower than it was anytime during 1973 or 1966, the years of severe shortages. Until we get additional coarse grain production, there will be increasing pressure on supplies of corn, sorghum, and other coarse grains. And when you have that kind of pressure, you can expect nothing but prices to go up.

Weather in the summer and fall of 1980 seriously reduced crop production and has had mixed effects upon our agriculture. It has meant that many farmers have been devastated by crop losses; on the other hand, it has had the effect of leading to rapidly escalating prices for the crops. The increasing crop prices bode well for increased fertilizer use during 1981.

Looking at corn, how does the crop/fertilizer price ratio stand now?

The price ratio corn to nitrogen is better than at anytime since 1974; much better and improving daily. The ratio on phosphate is equal to the best ratio since 1974, and it's also improving. The ratio on potash is still good.

In the spring of 1980 it took almost 100 bushels of corn to buy a ton of ammonia or urea. With the changing prices on corn and nitrogen, by August this had decreased to less than 70 bushels. Since then the ratio has improved even further.

The same is true with wheat. By August, advances in wheat prices had improved the ratio 20% as compared to spring 1980. Since then the price of wheat has continued its slow but steady upward trend, and the price of nitrogen certainly has not increased.

And with cattle and cotton these price ratios are approaching all-time records.

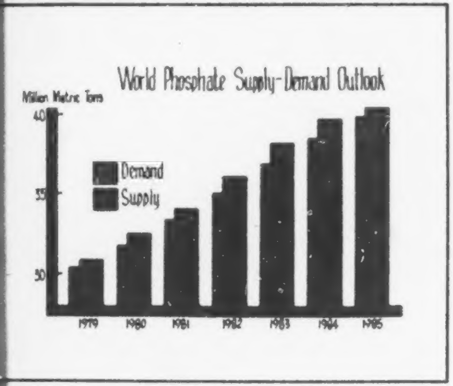
What is the supply/demand outlook, looking first at nitrogen?

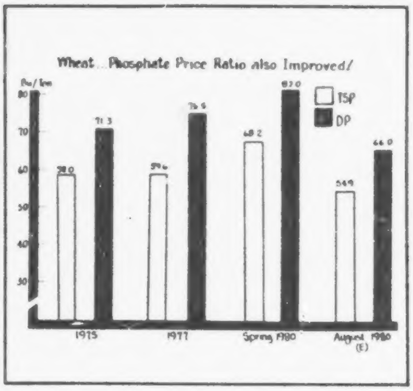
The bare statistics on numbers of plants coming on stream would indicate a significant worldwide surplus of materials in 1981 but statistics can be misleading. Much of the capacity cited is not real capacity; it's paper capacity. About 10% of the total world's production is based upon naphtha as feedstock. Those plants using naphtha or fuel oil as feedstock are paying $225/ton ammonia for the feedstock alone. The highest price I've heard recently was $180/ton ammonia in Europe, and it's certainly not that high here in the U.S. So you know that they won't be going all-out to produce ammonia in those plants, if they operate at all.

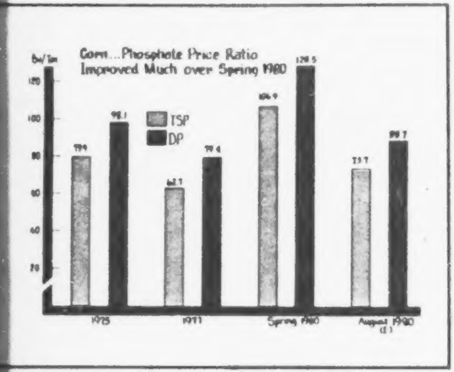
Another thing to be considered is the fact that much of the new capacity that is coming on stream is in the USSR. Even if Russia is able to produce the material, it is highly improbable that the world's logistics could be improved fast enough to make all this material available to the countries where it is needed.

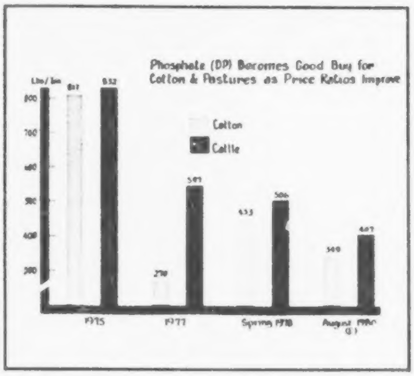
We can expect worldwide nitrogen demand to increase about 2½ to 3 million tons in 1981—if we can make it available. Supply will increase, but by no more than that—if as much. As a result, nitrogen will be in very tight equilibrium. The Iran/Iraq war has stopped the flow of some nitrogen, but this area accounts for only about 2% of the world's total production. If any other major nation should have a problem in production, we could have a severe shortage of nitrogen worldwide before the end of the year.

The U.S. nitrogen industry can well expect an all-time record in nitrogen sales in '81. In 1979–80 we surpassed the 11 million ton market for nitrogen









fertilizers for the first time in history. This fertilizer year we could well surpass 12 million, barring calamitous weather or other unforeseen catastrophic events.

On the supply side, in 1980 we produced an unexpectedly large amount of ammonia—18.8 million tons contrasted to only 17.2 million in 1979. This added production came about almost entirely by increasing the operating rate of the plants which were on stream. Only one or two of the plants which had earlier been closed because of economic problems were restarted. The net result was that those plants which were on stream operated at as high a rate of capacity as ever before in history. We cannot expect as large an increase during 1981 as that during '80.

Will some of the plants that have been mothballed be brought back into production?

There seems little economic reason whatsoever for a plant to open up as long as the price of ammonia stays as low as it is today. It's estimated that the average "spigot" production costs of ammonia now exceed $100/ton. And this figure doesn't include rate of return on investment or ammortization of the plant investment costs. With the cost of natural gas going up rapidly, we cannot expect additional plants to reopen as long as the price of ammonia on the Gulf Coast remains at or near its current level of $120.

What about supply/demand for phosphates?

It was clear in 1979 that the world supply/demand was coming to a very balanced situation. Then last spring we were faced with bad weather, high interest rates, and suddenly a sharp increase in phosphate prices. This decreased demand here and abroad; exports dropped and prices dropped. Beginning last fall, exports of diammonium phosphate (DAP), triple superphosphate, and phosphoric acid rebounded sharply. We are now exporting more phosphate than ever before. The first four months of the year we exported 20% more concentrated phosphates than we did last year, and last year we exported the most in our history. We exported 28% more DAP than we did in the first four months of the 1979–80 fertilizer year, and 114% more monoammonium phosphate. The future looks bright for export of all phosphates.

Last year farmers cut back on their fertilizer use, particularly phosphates. What do you think will happen this year?

I strongly believe that phosphate use will rebound and we will have an increase this year of 3–5% over the 1978–79 use level. We'll regain the tonnage lost in '79–80, plus an additional 3–5% in the amount of phosphate used.

With export demand high and a big increase in domestic demand, supply/demand is going to be in very close balance. If the embargo on shipments of P_2O_5 to Russia is removed and we start shipping phosphoric acid to Russia in addition to our other exports, we could easily run into a very tight situation on phosphate in late spring. If demand increases more than expected or if we should run into a major breakdown in a plant or two, we could run into a real shortage.

What's the situation in potash?

Canada is producing more potash than a year ago, but they are exporting at a rate 30% higher than they did last year. U.S. dealers did not take potash deliveries in the fall as rapidly as the previous year and as a result, the Canadians have been forced to ship overseas. By failing to follow a normal ordering pattern, dealers may find that they have been outbid by foreign users.

Last year it was clear, looking at the month-to-month statistics, that exports were being held down in order to insure enough material being available in the spring for the North American farmer. Exports all during the fall of '79 were held down artificially by the sellers. We know of several countries that did not get any potash that needed it, of several invitations for bid that were not answered. In the fall of 1980, since the North American user wasn't ordering, exports were up 25 to 30%.

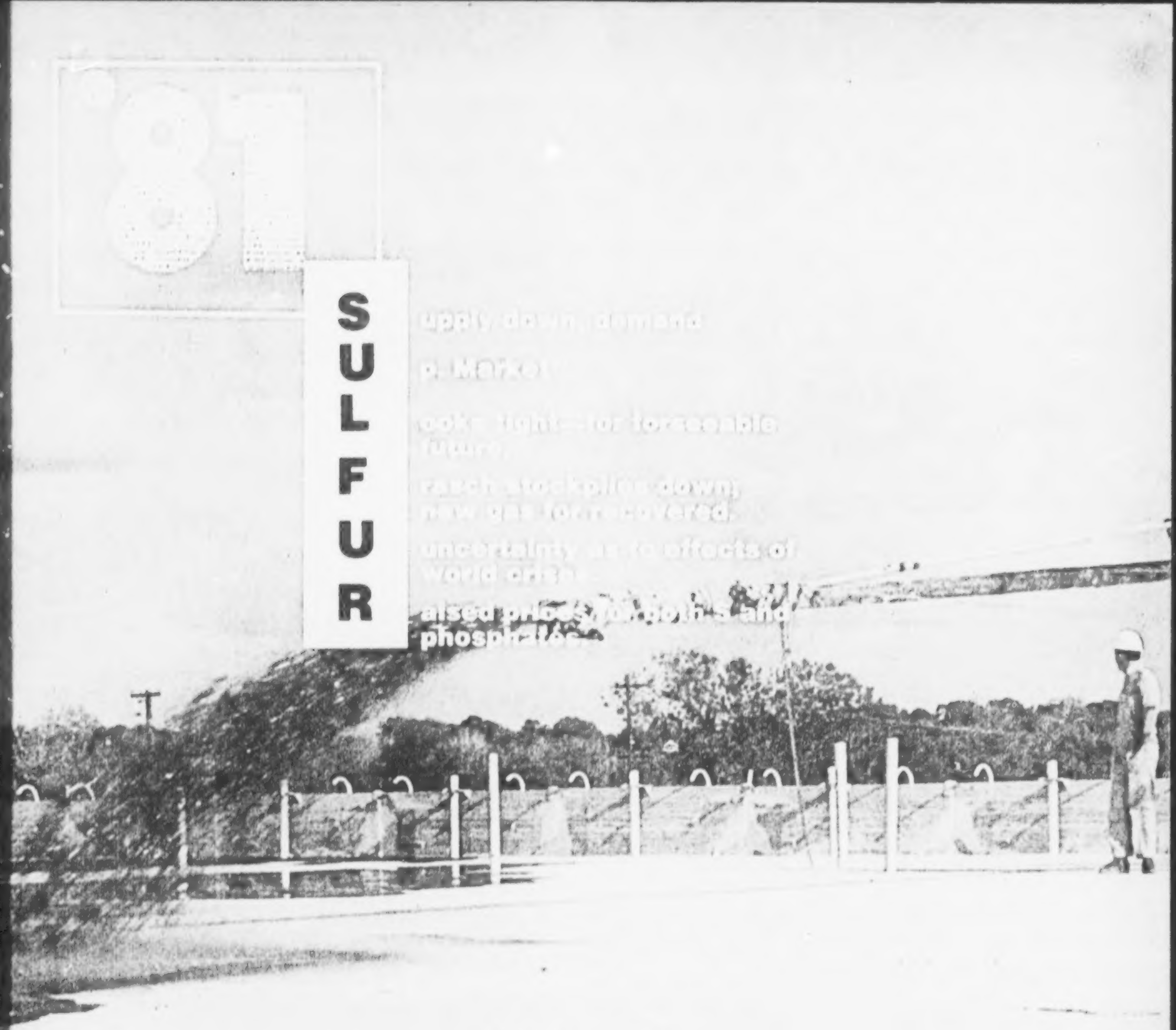
With the increased production available in Canada and if we guess right about what is needed in North America and don't export too much, we should have ample supplies of potash available. But there will be nothing left over in inventory.

Summing up, what's your advice to dealers?

Be aware of the close supply/demand equilibrium. In my 30 years in the industry, I have never seen a time when all three plant nutrients were in as tight a supply/demand balance as they are today. The dealer should be aware that if he doesn't order now, he may have an extreme problem and delay in getting materials in the spring—if he gets them at all. The dealer is in a real dilemma; with the high interest rates, he has to worry about the cost of carrying materials for several months. He's going to have to do some careful planning, judge what he thinks his farmers are going to use, and order at least a portion of his materials now. It's a time for careful forward planning. He's going to have to look at the situation objectively and judge for himself how much he can afford to carry in inventory.

What's your advice for the producers?

Produce every ton of material you can. It'll be used! **FC**



SULFUR

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rasch stockpiles down; new gas form recovered.

uncertainty as to effects of world crisis

aised prices for both S and phosphates.

THE best word to describe the sulfur market these days is "tight." "Tighter in real terms," says Bill Mason, sales manager for sulfur at Texasgulf, "than we've seen it for some time."

Why? "What we've been seeing in the sulfur market is a recurrence of problems such as rising shipping and production expenses and world crises, which have caused logistical shortages," says Mason. And at the same time, demand has gone up, led by the phosphate fertilizer producers (who account for 50% of U.S. sulfur usage) and the industrial sector.

Mason believes this tightness has come as somewhat of a surprise to many in the industry. A number of people had been under the impression that the recession would take its toll and free up a lot of product.

In a report before the Fertilizer Industry Round Table in October, D. W. Bixby, director of fertilizer technology research with The Sulphur Institute, summed up the early 1980 consensus: "The outlook in the U.S. for P_2O_5 consumption became more discouraging because of the tightening of credit, an unfavorable crop:phosphate price ratio, the Russian embargo, and bad weather. Since then, I understand matters have improved somewhat for the first two items."

So it would seem. As Mason points out, "The real effects of the recession in the U.S. were not as dramatic to the sulfur industry as one might expect. Demand has been good from both fertilizer and industrial sectors, but the real leader has been the strong demand by phosphate producers."

He sees two factors on the phosphate front that have kept demand so high. One, the replenishment of inventory in anticipation of high demand next year, and two, strong exports of finished phosphate products.

Bixby agrees that phosphate sales will probably be higher in the future. "My guess is that the positive effects of increased crop prices and high grain exports will offset the negative effects of the drought seen in large sectors of the U.S. and Canada and a decline in the total farm income in '80–'81 with a modest growth resuming in '81–'82."

It's Going To Cost *How* Much?

Inevitably a tight market has its effects on prices, so where will U.S. prices go? At this writing, Texasgulf very recently had announced a $12.50 increase in its contract sulfur prices—up to $140 per ton, FOB Tampa. How-

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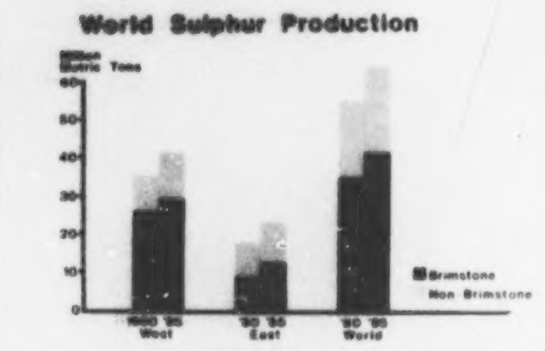

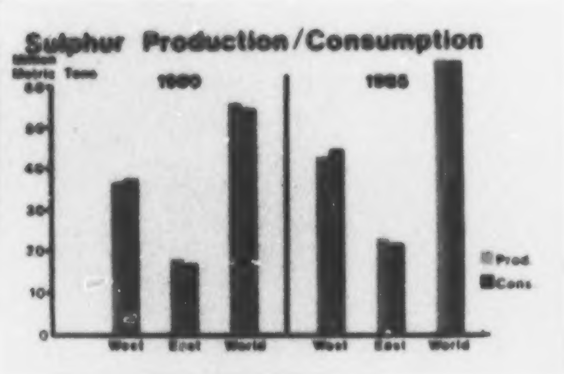

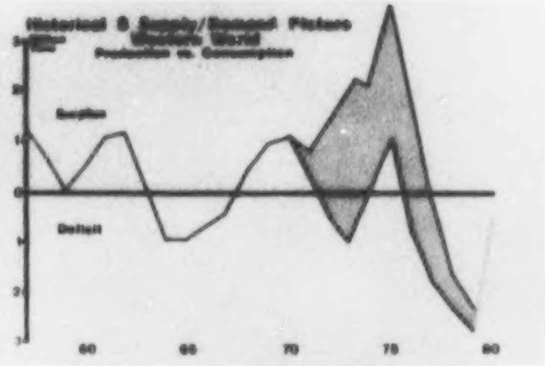

ever, neither Freeport nor Duval had as yet announced whether they would be chalking up similar increases. Still, there are probably few bets against further price hikes.

Sulphur, journal of the British Sulphur Corp., Ltd., in its July/August issue reported that "The factors pointing towards a general rise in contract prices . . . are unquestionable. Suppliers have been unable to meet heavy sulfur demands from present production levels and have continually drawn on stocks . . ."

While declining to reveal specific figures, Mason pointed out a few truisms that affect the pricing situation. "Sulfur is a cyclical commodity, and sensitive to supply and demand curves. Historically, prices must increase during times of peak demand. When demand is down, prices become flat; but you still have ongoing costs to cope with, which are now up."

Actually, Mason foresees little possibility for reduction in Frasch prices considering the "energy intensiveness of Frasch production. It's already costly, but I think the cost of producing, handling, and shipping sulfur is going to continue to rise."

Much of the upward spiral lies in natural gas, which is used in Frasch production as a fuel. Although Texasgulf, like other Frasch producers, has looked into the possibility of converting to coal as an alternative, "At the present time," reveals Mason, "the costs to convert our operations are just prohibitive." He expects that natural gas prices will have effects on sulfur prices in the future but allows the situation can't really be quantified at present.

The effect of all this on phosphate prices must be examined from a couple of vantage points. On the one hand, phosphates require a heap of sulfuric acid—89% for P_2O_5, and 50% for DAP. So, answers Mason, "I think the higher cost of sulfur will certainly have its effect on the attitudes of phosphate manufacturers."

On the other hand, upped sulfur prices will not *necessarily* translate to higher phosphate prices. "The fertilizer market has a set of factors that are independent of sulfur. So the prices don't necessarily go hand in hand," Mason points out. "Certainly, a reduction in the price of sulfur would not always translate into a phosphate reduction. There are a host of marketing principles and policies of all the companies in the country that have a bearing.

"However, I do think that the price of sulfur as a raw material going into phosphate production is a very definite factor that needs to be contended with, and it can't help but affect the attitude of the producers."

The Trade Off

Texasgulf president Dr. Gino Giusti, in a talk at The Fertilizer Institute's international marketing conference in June, presented figures on western world supply versus demand, and it looks as though tightness will be the watchword for years to come.

For 1979, he reports consumption of 38.4 million tons and production of 35.7. Five years hence, he estimates consumption will stand at 47 million tons compared with 42.6 million tons of production. And for 1990, consumption of 55 million tons is predicted, with production at about 49 million tons—a 6 million ton shortfall.

A quote from TSI's Dr. Bixby may be appropriate at this point. Prefacing his own forecast, he remarked, "The only thing certain about a five-year projection in sulfur supply and demand is that it will be wrong." He agrees with Giusti, though, that for the foreseeable future, demand will prob-

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ably continue to outstrip supply in the West.

"The key element of this shortfall for the industry," predicts Mason, "is going to come in inventory. Stockpiles—especially Frasch—have dropped significantly and are expected to continue to do so. In fact, during the first 6 months of 1980, U.S. inventory dropped in the range of 800,000 tons. By year's end (he was speaking in early December), it will be decreased by a total of about 1.4 million tons.

"What you're seeing is a total U.S. stockpile of roughly 3 million tons by year's end 1980. And since the U.S. consumes about 12 million tons a year, that means stockpiles are getting to be about 25%. I think that's a dangerously low level; and if they're reduced much further, we could be in a very, very dangerous position."

What then? For one thing, Frasch producers have increased exploration for new sources. Freeport has already begun production at a new mine at Caillou Island, LA. Remarking that the "deposit is a small one with a relatively short life," Freeport president R. L. Williams said, "Ordinarily it would not have been economical to mine this deposit." The go-ahead for the 350,000 ton per year operation came about because of improved sulfur prices "and the need to rebuild our inventories."

It appears the bulk of new production in the U.S. will likely be recovered sulfur—primarily from the Overthrust sour gas of Wyoming and from gas fields in Mississippi and Alabama. According to Mason, "Judging from preliminary indications, the Overthrust alone will probably produce in the range of 2–3000 tons a day when it comes on stream."

He postulates there may be as much as a 50–75% increase in recovered sulfur by 1982–83, depending on the new gas and on increased production from refineries that have cut back at present.

For the long-term shortfall, though, it's uncertain where the additional material will come from. However, Bixby sounds rather confident that new sources will rise to meet the need: "There is, after all, plenty of sulfur in the world . . . It will be obtained from pyrites and other compounds when economics justify it, but that day has not yet come."

Concerning pollution abatement sulfur: "Until 1990, it may do little more than replace declining . . . production, barring new discoveries."

The continuing (and imminent) hostilities in the Middle East are quite potentially a large rag in the gears of the western sulfur industry. "A prolonged war there," Mason reflects, "could cause very serious imbalance repercussions on the world sulfur trade. About 5% of the world sulfur supply comes from this area, and, of course, Iran provides natural gas to Poland for sulfur production. The interruptions there have already cut into productivity."

The wave of strikes that wrenched Poland in the summer apparently also have had a sizeable effect on the disposition of Polish sulfur. According to one source, the strikes, coupled with the cutoff of Iranian supplies, may result in Poland's being able to export only 20–25% of a potential 4 million metric tons.

One outcome of the crisis situations has been that certain markets traditionally supplied from the Middle East have turned to North America for their sulfur supplies. Thus far, Canada and the U.S. have done a good job of meeting these needs. Last year's million ton shortfall from Iran and Poland was made up by removing 1.3 million tons from inventory, 1.1 million of which came from U.S. Frasch producers.

In any event, some industry voices believe that only the alleviation of the Middle East crises can prevent serious imbalances in the future. **FC**

Why Sulfur Demand Is Increasing

DR. SAMUEL TISDALE, president and chief agronomist at the Sulphur Institute, thinks U.S. and Canadian farmers will use sulfur in greater quantities as deficiencies of the nutrient become more apparent.

"Two decades ago, sulfur deficiencies had been identified in 13 states," says Tisdale. "By 1978, the number had grown to 35, and every Canadian province from Ontario west was reporting deficiencies of this vital nutrient.

"If today's need for sulfur is any indication of the anticipated demand," he continues, "I think we'll see a dramatic increase in the use of sulfur fertilizers in this decade."

"Sulfur, while not usually ranked as a macronutrient, is equal in importance to N and P in the formation of protein," says Tisdale. "Many crops require as much S as they do P for maximum yield; some require more."

Tisdale explains that most commercial fertilizers used before the 1950s contained large amounts of S as impurities. Ordinary superphosphate, with 12% S, and ammonium sulfate, with 24%, were two of the most widely used sources of P and N. In effect, growers were getting significant amounts of S in their normal fertility programs. Today, however, agriculture relies primarily on much higher analysis sources of N and P, most of which have little or no sulfur. Even the reduced usage of sulfur-rich feedlot manure has played a role.

As a result, in the past 30 years, total S as a percent of NPKS plummetted from 31.3% to less than 6%.

While additions of S to U.S. and Canadian crop soils have been decreasing over that time, the removal of S from the soil has been going the other way. Average corn yields during this 30-year period have approximately doubled, and for every 150 bushels of corn harvested, 27–33 pounds of S are harvested, too. Cotton, tobacco, grain sorghum, alfalfa, clover, many grass species, sugar beets, and a variety of vegetable and fruit crops remove even greater amounts of S from the soil. Even with wheat, which has a relatively low sulfur content, 9–12 pounds of the element are removed from the field when a grower combines a 40 bushels-per-acre crop.

Like other traditional sources, atmospheric sulfur is providing less S to agricultural lands than in the past. From 1970 to 1975, EPA measurements showed a 30% decrease in the levels of sulfur dioxide released into the air over urban areas. Sulfur oxide emissions from all sources were down by 4%.

"No one is suggesting that sulfur oxide pollution be allowed to increase in order to improve crop yields," Tisdale says. "These pollutants can be corrosive and poisonous. The point is that farmers in all regions should be aware of how the control of sulfur oxide pollution and the absence of S in high-analysis fertilizers can short their crops on this vital plant nutrient.

"There are a wide variety of S fertilizers available at costs far below those for N and P," he points out.

In areas where the nutrient is needed, farmers can expect a $4–$10 return in yield on every dollar invested in sulfur, Tisdale adds. **FC**

For Details Circle No. 109 on Postcard →

'81

K_2O Faces a SQUEEZE

During the next five years, the supply: demand ratio for potash will go from tight to tighter, claims an industry expert.

ORDER your potash early and don't expect price reductions because the market probably will be tight. That's the advice of Dean R. Gidney, Potash Co. of America, while making what he calls his "stock annual plea to take deliveries of potash and other materials as soon as possible" at the annual meeting of the Fertilizer Industry Round Table. But is it even more important to heed his advice this year than it was in the past?

"In looking forward to the current fertilizer year, we don't see any reason to expect very much change in the tight supply/demand balance," Gidney explains. "With the usual qualifications concerning weather, farm income, farm prices, etc., we foresee a good domestic season in 1980–81."

Anticipating a demand for increased deliveries this spring, he continues, "We will be faced with the usual logistic problems. Even despite the fact that there will be an adequate supply of potash, you will once again be faced with the unavailability of some grades at some times and places."

A veteran forecaster, Gidney has been making annual predictions since the 1940s when, as he describes it, the fertilizer industry was "an industry of manure and kainite." Over the years he has been more on target than off.

In 1958, for instance, he predicted that China would be a large potential market in 20 years. Today that country is holding 3-year contracts for 650,000 tons from Canpotex; 100,000 tons from Western Europe; 160,000 tons from PCA; and is rumored to be negotiating with Spain. Gidney thinks this indicates demand will grow even more dramatically, making his 1984–85 Asian predictions too low. (See Table.)

Other countries, too, are closing the gap between supply and demand at such a rate that Gidney believes the industry should have a "knife-edge balance" by 1984–85.

Who Supplies, Who Demands?

As far as production is concerned during the next 5-year period, Gidney believes the major increases will be in Canada and the USSR, although he does not think the Russians will meet their stated goals. (His table reflects this, and the figures are his own.)

Capacities in Saskatoon will be expanded, and PCA's new mine in New Brunswick will be producing perhaps as early as next year, coming close to rated capacity in 1983. He suspects the Denison/Potacan project, also in New Brunswick, will become productive at least a year later.

In addition, he says, "Minor increases in capacity are in process at three of the private industry companies in Saskatoon (PCA, Kalium, and Cominco), and the Potash Corp. of Saskatchewan has announced its intention to make major expansions over the next decade. The major expansion at the Lanigan mine of approximately 1 million metric tons of K_2O will be completed by 1983, and an entirely new mine at Bredenbury is expected to produce 3.6 million short tons a year of potassium chloride by 1985—that's approximately 1.95 million metric tons of K_2O." If all comes to fruition, he points out, the figures on his chart for North America would be short by at least a million metric tons of K_2O.

1984/85
Estimated World Production and Consumption of Potash (1000 Metric Tons K_2O)

	Production	Consumption	Surplus (Deficit)
North America	11,800	7,500	4,300
Western Europe (inc. Israel)	6,800	6,800	—
Eastern Europe	14,000	12,400	1,600
Latin America (1)	400	2,400	(2,000)
Asia & Oceania	200	3,400	(3,200)
Africa Mideast (2)	500	600	(100)
TOTALS	33,700	33,100	600

(1) Includes potential production in Brazil.
(2) Includes anticipated production in Jordan.

Off the North American continent, he foresees European capacity strengthened from the Dead Sea works in Israel, possibly operative by the end of 1981. Jordan's mines in the Dead Sea area may be productive by 1983. With the help of technical advisors from France, Brazil's mine in the state of Sergipe may be in operation by 1984–85.

The largest consuming areas of potash, according to Gidney, will continue to be its producing areas, and in the direct order of the amount of production: Eastern Europe, North America, Western Europe. Other markets, says Gidney, must be developed and increased.

In Asia, Japan and India should continue as good consumers, while Korea and Taiwan rapidly expand their demands. As previously stated, the PRC has entered the picture. In Latin America, Brazil remains the principal consumer.

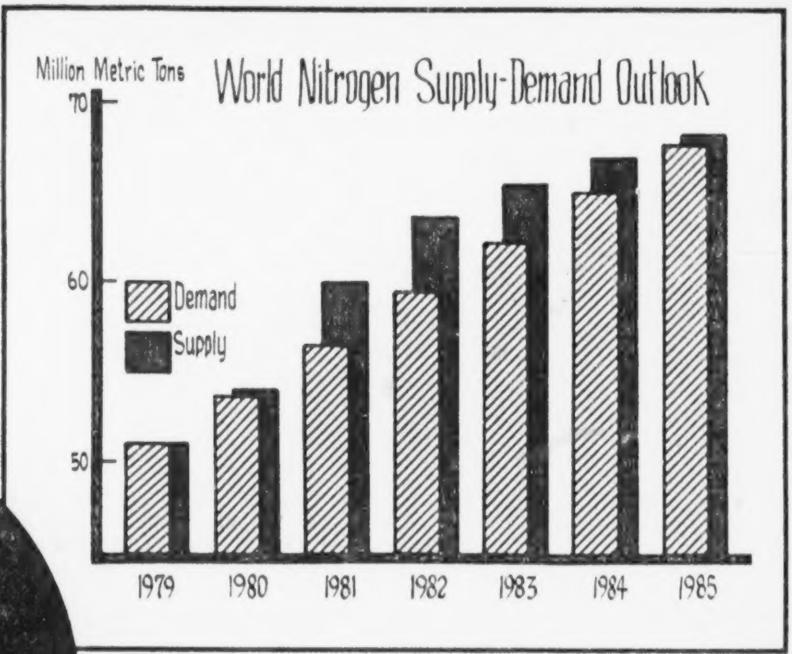
"We recognize the fact that Brazil has serious economic and monetary problems," explains Gidney, "but agriculture is as important to Brazil as it is to the U.S.A. Export crops are essential to the Brazilian economy, and virtually every cash crop in Brazil is a large user of potash. For this reason, we believe that some solution to the payment problem must be worked out and foresee a continuing expansion in that market."

Gidney reiterates a point he makes annually along with his predictions, "The potash market is a *world* market, and it is *world* supply and demand which determines the potash balance."

For this reason, he stresses, "We must increase the potash consumption in other of the lesser developed countries in the world. But this is a slow process contingent upon education and financing, and it is in the area of education that the potash industry takes its greatest pride." **FC**

'81

NH$_3$ OUTLOOK at a GLANCE



Summary... World Situation... 1981

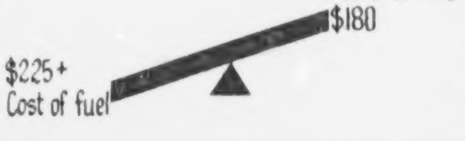
Demand..... Increase as expected by 2.5-3.0 million tons

Supply....... Increase... but not nearly as much as capacity statistics would indicate

Supply-Demand Balance..... Tight equilibrium

At the Fertilizer Industry Round Table in late October, Dr. John Douglas of TVA presented this analysis of the situation in nitrogen. He predicts there'll be increasing pressure on all nitrogen supplies once we get into the spring, with some probability of spot tightness or even shortages.

For 10% of Worlds Production Feedstock Costs more than NH$_3$



Export-Import Picture... U.S... 1000 Tons

1979

Net Exports... About 200

1980

Exports Increased... About 100

Imports Increased ... About 400

Net Balance............ <100 Net Imports

1981 Projection

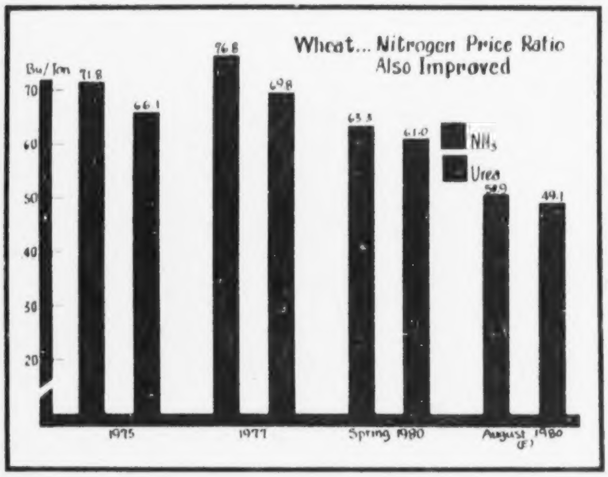
Exports................ Increase 8-10%

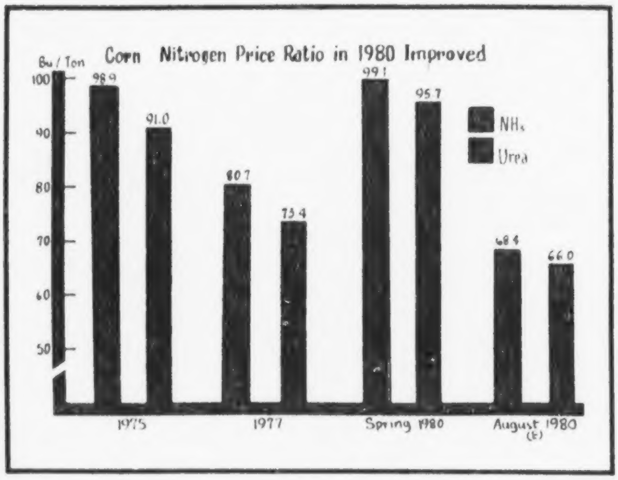
Imports................ Increase NH$_3$ by 500 decrease other imports

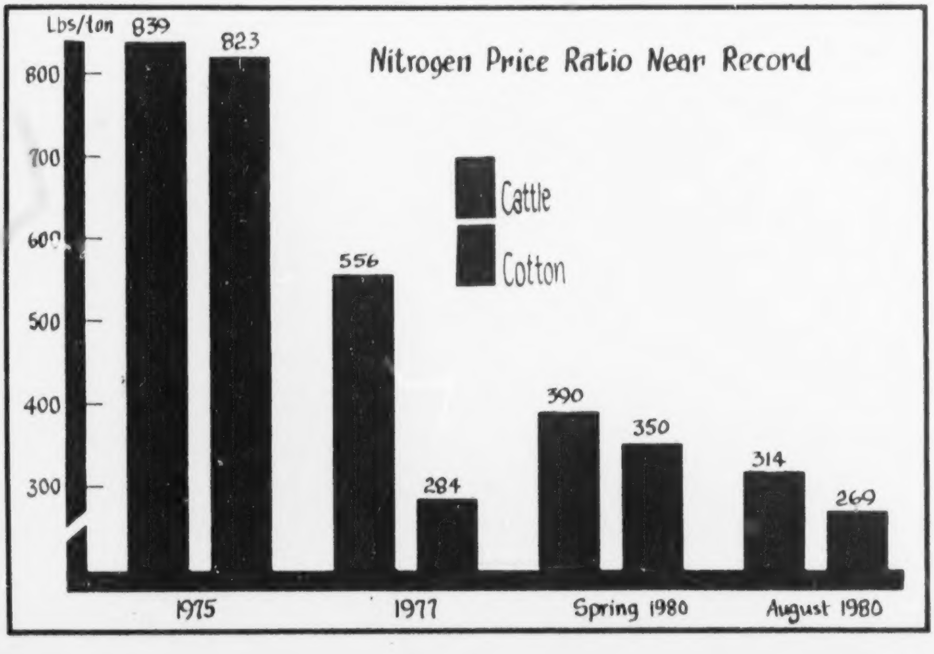
Net Trade Balance...... 0 ± 250

Nitrogen...Supply-Demand Summary 1981

- Supplies ample
- Domestic demand, up, but fall of 1980 may be slow
- Export demand should increase for urea and nitrogen solutions
- Generally tight situation after slow fall
- Increasing pressure on supplies after fall 1980


Wheat... Nitrogen Price Ratio Also Improved


Corn Nitrogen Price Ratio in 1980 Improved


Nitrogen Price Ratio Near Record

'81

Feedstocks:

SUPPLY and demand—usually without one, the other suffers. Paradoxically there is an overadequate supply to meet the demand for one product this year, yet that product is more costly than ever before.

The product is natural gas, vital to the chemical industry which uses 11% of the total U.S.-consumed 20 trillion cubic feet annually. The supply is abundant and "overdeliverable" if anything, says the American Gas Association. But because the chemical industry and residential customers have cut their total gas demands 22.1% and 13.6% respectively, natural gas prices will continue to rise—as much as 20% per year over the next few years, predicts DuPont, and perhaps 25% in the Midwest and California.

It is understandable then that industry is looking for alternate feedstocks.

National Distillers and Chemical, parent company of U.S.I. Chemicals and Emery Industries, has been long involved with producing ethanol through a fermentation process. Before 1950 the alcohol produced provided the major feedstock for several chemicals, and the company hopes this practice will be revived.

National owns 16% of Cetus, a genetic engineering firm, and the two have developed a continuous fermentation process. National chairman Drummond C. Bell foresees considerable savings over the traditional batch method because energy demand would be reduced by running the process at a constant temperature.

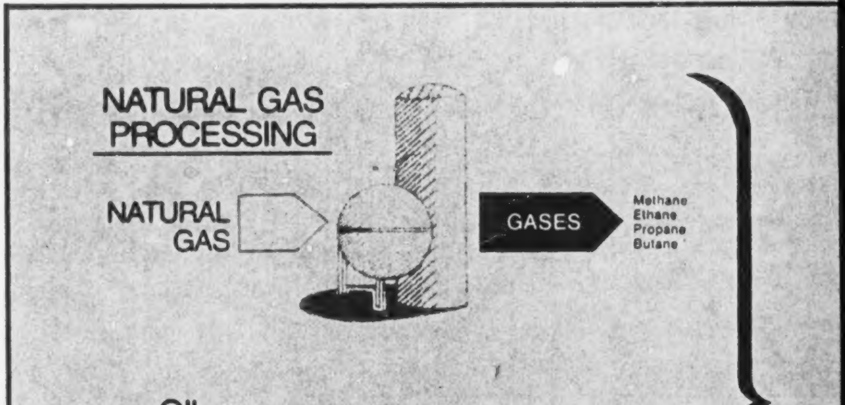
When pilot plant production begins this year, the feedstock will be corn starch; but by 1983 when commercial production is slated to start up, the feedstock could be cellulose or municipal waste. Adds executive vice-president Clifford Oman, head of National's chemical operations, if successful the process will free expensive ethylene for other uses.

"During the 1980s we are going to see very slow development," concedes Bell. "The 1980s will be the syn gas (for synthetic gas) decade. The 1990s will see an explosion of DNA technology." Operational problems are the reason for slow progress, but the recent development of a low-pressure, low-density process may help to make National more competitive.

Syn Gas: Getting the Nod?

H. A. Sorgenti, president of Arco Chemical Co., agrees that syn gas is coming into its own, though not so quickly. He explains that in theory any organic can be built from synthesis gas, but in practice oxygen-containing intermediates "will get the nod." Three syn gasses are already commercially successful (methanol, acetic acid/acetic anhydride, and 2-ethylhexyl alcohol) and five more have high potential (ethylene glycol, adipic acid/caprolactam, terephthalic acid, methyl methacrylate, and vinyl acetate).

However, Sorgenti finds there are limits for syn gas chemistry. "We al-



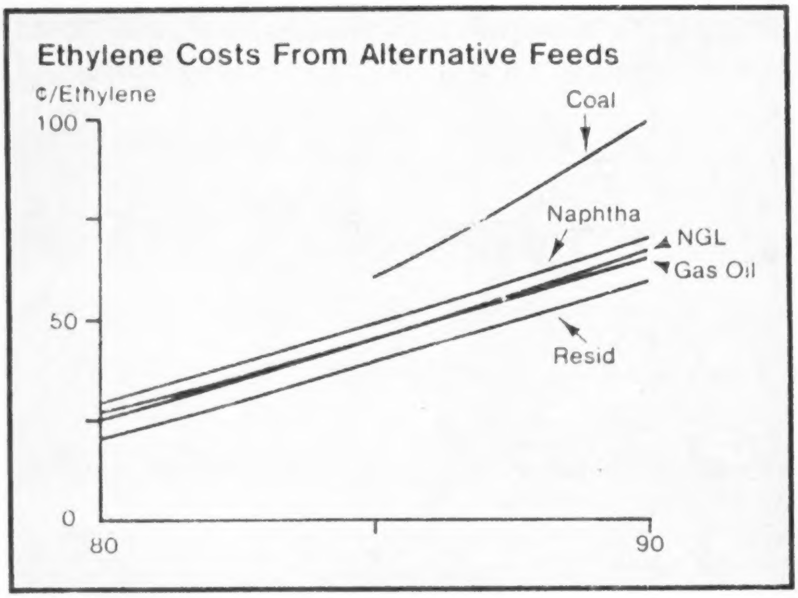
This chart, produced by Exxon Corp., shows the dependence of fertilizers and pesticides on petrochemicals.

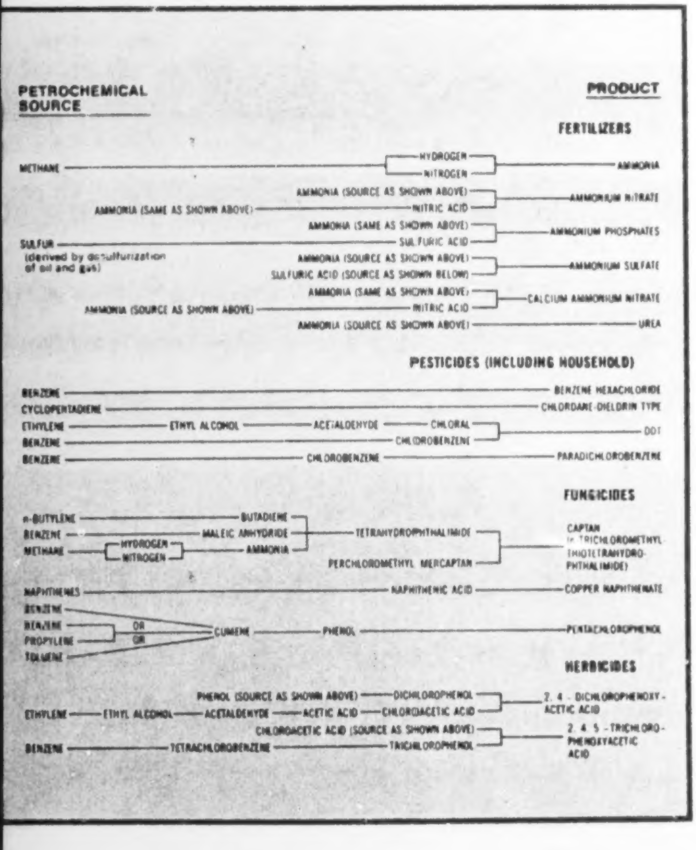
A Decade of Change

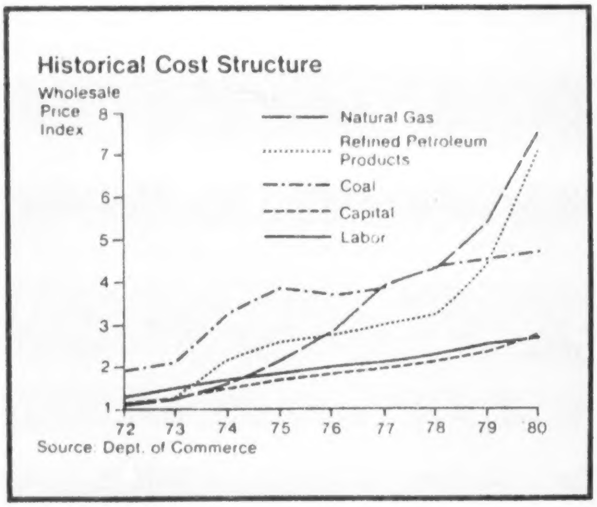
As natural gas becomes more plentiful and more expensive, industry searches for a viable substitute.

ready use synthesis gas for methanol and oxo-alcohol production. In each of these, there is a 100% theoretical yield of raw material, both carbon and oxygen. This points to a key consideration for chemicals which will be the likely economical uses of syn gas. In ethanol, ethylene, and benzene, a major portion of the feed mass is lost as water. This is a tough penalty which I doubt can be overcome," he explains.

He believes that syn gas will be made economically from coal only after "a significant breakthrough." Pointing out that the high level of research activity in industry today "creates the potential" for this breakthrough, Sorgenti says for the present "the cost of syn gas from coal is above the value of methanol. The syn gas cost is driven there, despite lower feedstock cost, by the high capital




PETROCHEMICAL SOURCE
PRODUCT
FERTILIZERS
METHANE
HYDROGEN
NITROGEN
AMMONIA
AMMONIA (SOURCE AS SHOWN ABOVE)
AMMONIA (SAME AS SHOWN ABOVE)
NITRIC ACID
AMMONIUM NITRATE
AMMONIA (SAME AS SHOWN ABOVE)
SULFUR
(derived by desulfurization of oil and gas)
SULFURIC ACID
AMMONIUM PHOSPHATES
AMMONIA (SOURCE AS SHOWN ABOVE)
SULFURIC ACID (SOURCE AS SHOWN BELOW)
AMMONIUM SULFATE
AMMONIA (SAME AS SHOWN ABOVE)
AMMONIA (SOURCE AS SHOWN ABOVE)
NITRIC ACID
CALCIUM AMMONIUM NITRATE
AMMONIA (SOURCE AS SHOWN ABOVE)
UREA
PESTICIDES (INCLUDING HOUSEHOLD)
BENZENE
BENZENE HEXACHLORIDE
CYCLOPENTADIENE
CHLORDANE-DIELDRIN TYPE
ETHYLENE
ETHYL ALCOHOL
ACETALDEHYDE
CHLORAL
BENZENE
CHLOROBENZENE
DDT
BENZENE
CHLOROBENZENE
PARADICHLOROBENZENE
FUNGICIDES
n-BUTYLENE
BUTADIENE
BENZENE
MALEIC ANHYDRIDE
METHANE
HYDROGEN
NITROGEN
AMMONIA
TETRAHYDROPHTHALIMIDE
PERCHLOROMETHYL MERCAPTAN
CAPTAN (N-TRICHLOROMETHYL THIOTETRAHYDRO-PHTHALIMIDE)
NAPHTHENES
NAPHTHENIC ACID
COPPER NAPHTHENATE
BENZENE
BENZENE
PROPYLENE
OR
OR
TOLUENE
CUMENE
PHENOL
PENTACHLOROPHENOL
HERBICIDES
PHENOL (SOURCE AS SHOWN ABOVE)
DICHLOROPHENOL
ETHYLENE
ETHYL ALCOHOL
ACETALDEHYDE
ACETIC ACID
CHLOROACETIC ACID
2, 4 - DICHLOROPHENOXY-ACETIC ACID
CHLOROACETIC ACID (SOURCE AS SHOWN ABOVE)
BENZENE
TETRACHLOROBENZENE
TRICHLOROPHENOL
2, 4, 5 -TRICHLORO-PHENOXYACETIC ACID



Source: Dept. of Commerce

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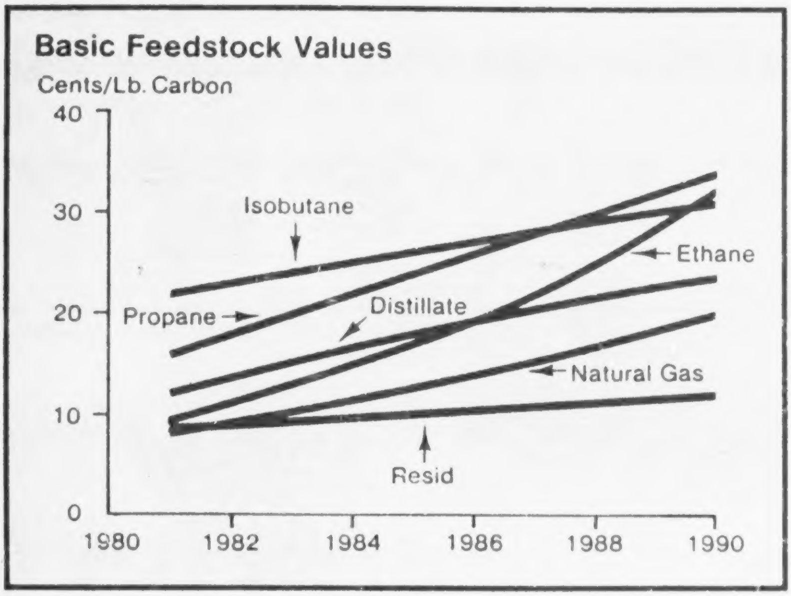
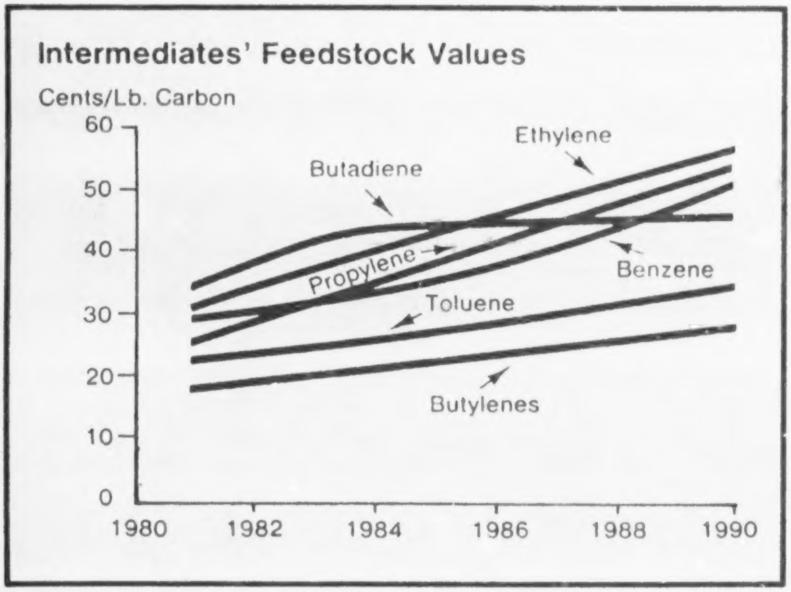

Basic Feedstock Values


Intermediates' Feedstock Values

charges associated with synthesis gas made from coal.

"We are looking at the early 1990s before a full fledged syn gas industry based on coal could begin to be an important factor," he continues. "Our own methanol plant (200 million gallons) is based on natural gas. We expect with time to shift the synthesis gas portion of this plant to natural gas liquids, naphtha, or resid, and finally coal."

Note that Sorgenti does not predict a "rapid shift away from petroleum and natural gas as a source of feedstock for organic chemicals." He explains, "Although the cost of energy, and hence our feedstocks, has risen dramatically, our industry consumes only 5% of today's total energy demand. By 1990, this figure will only be about 8%. At the same time, you are all familiar with the relative value of fuels to the organic products we make. The economists tell us we should win the battle for these raw materials.

"Conversely, this says the adjustments in the use of crude and natural gas caused by these relative shifts in value are more likely to occur on the fuels side. Just think about it for a minute. Isn't this what you have already seen? How many power plants have already been converted to coal? Higher MPG requirements for autos and lower gasoline demand are a response to higher fuels costs. The trend is established and observable. We see coal usage equivalent to 11 million barrels per day by 1990, and almost all of it will be for its most efficient use—fuel."

Predicting trends in costs of basic feedstocks, Sorgenti says, "Heavy feedstocks will become cheaper relative to other sources of carbons, particularly natural gas liquids, in an increasingly free market. Both of these conventional sources of hydrocarbons, however, will remain the basic source of organic chemicals throughout the remainder of the century.

"Different views of relative feedstock values are possible, but we can agree that all feedstock values will be increasing. Therefore, the real challenge is to use these feedstocks as efficiently as possible."

Again, looking ahead, Sorgenti emphasizes, "We have not suggested any radical changes. The really significant potential for shifts in feedstock in the next 20 years will most likely come in the stages of production after the basics. The basic chemicals, olefins and aromatics, are themselves feedstocks. Butylenes, butadiene, and toluene will offer significant cost advantages over the next decade. Innumerable opportunities will present themselves for improved and new processes.

"The next 10 years will be a process engineer's delight. Processes which are simpler, utilize lower cost feedstocks, give higher yields even at the expense of higher capital, give greater flexibility in feedstock, give lower energy consumption, and yield purer products will be favored. These will be the major structural changes which are likely to occur as the industry tries to make better use of more precious feedstocks." **FC**

Pollen Product Prospers Plants

JOHN YOPP, a plant physiologist at Southern Illinois University, Carbondale, believes a lab copy of a powerful plant steroidal lactone found in pollen could help growers "dramatically increase" yields. The modified steroid—known in its natural form as brassinolide—seems to influence root growth, fruit set, and "just about all aspects of plant growth."

The modified steroid, part of a group of plant chemicals called brassino steroids, occurs naturally in the pollen from rape blossoms. Although discovered in the 1940s by USDA scientist John Mitchell, development of the chemical was hindered by criticism from other researchers and the fact that the steroid occurs naturally only in very small quantities.

"You get only a few milligrams from a hundred pounds of pollen," says Yopp.

He notes that brassinolide appears to act with auxin, a naturally-occurring plant hormone, to produce the increased growth. The two compounds seem to potentiate, increasing the effect of auxin many hundredfold.

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FARM CHEMICALS

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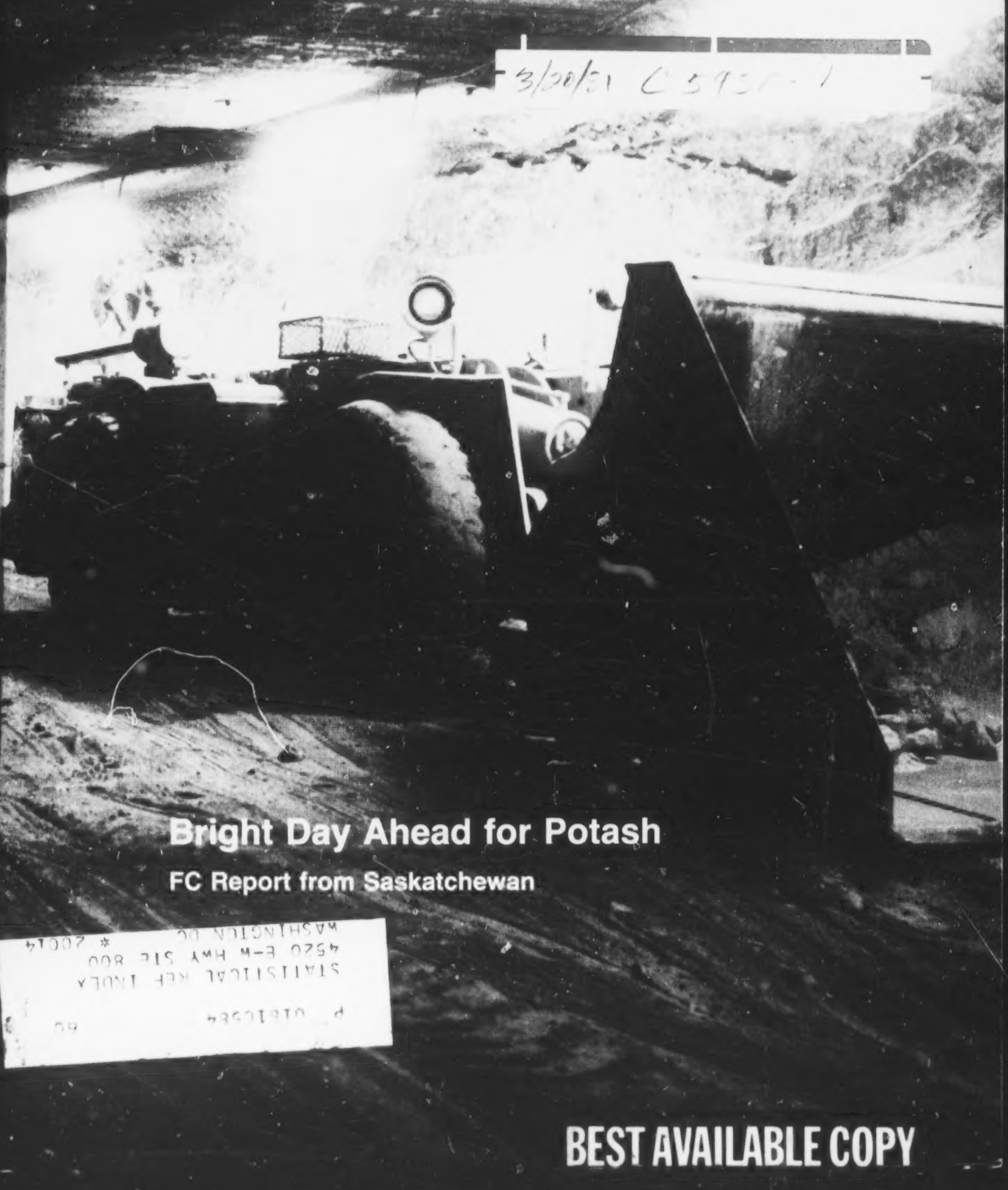

Bright Day Ahead for Potash

FC Report from Saskatchewan

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THE COVER STORY

There are bright days ahead for Saskatchewan potash. Supply/demand is tightening, leading to expansions and new mines. For the full story, see FC's Report from Saskatchewan beginning on page 13. *(Photo courtesy Potash Corporation of Saskatchewan.)*

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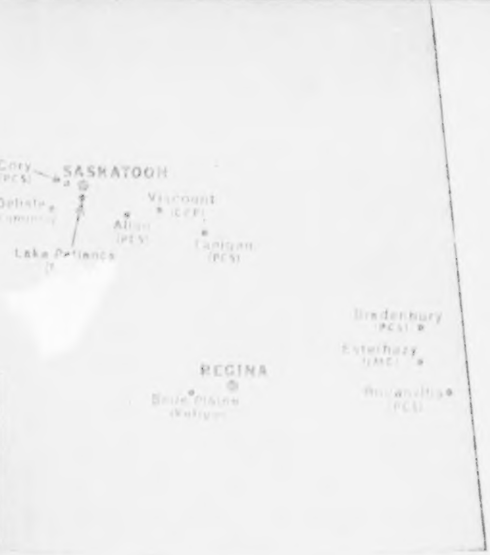
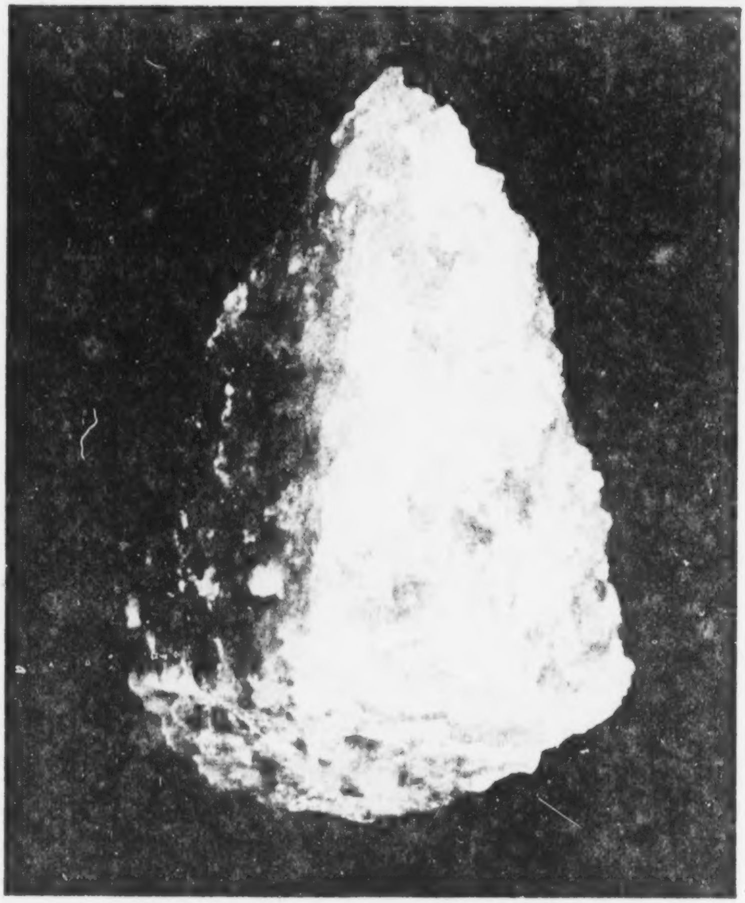




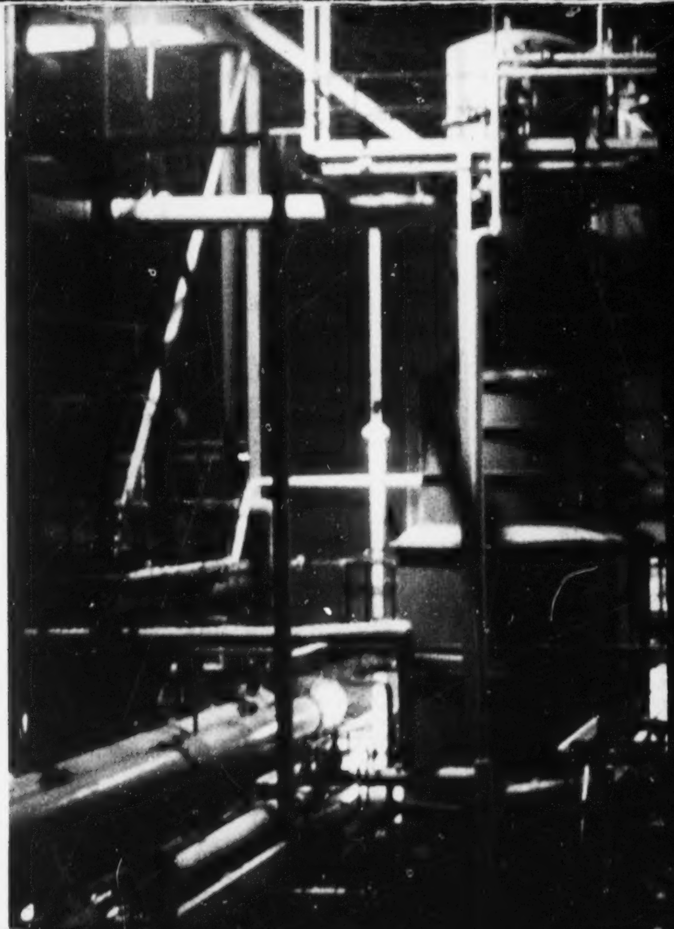
BRIGHT DAYS AHEAD FOR POTASH

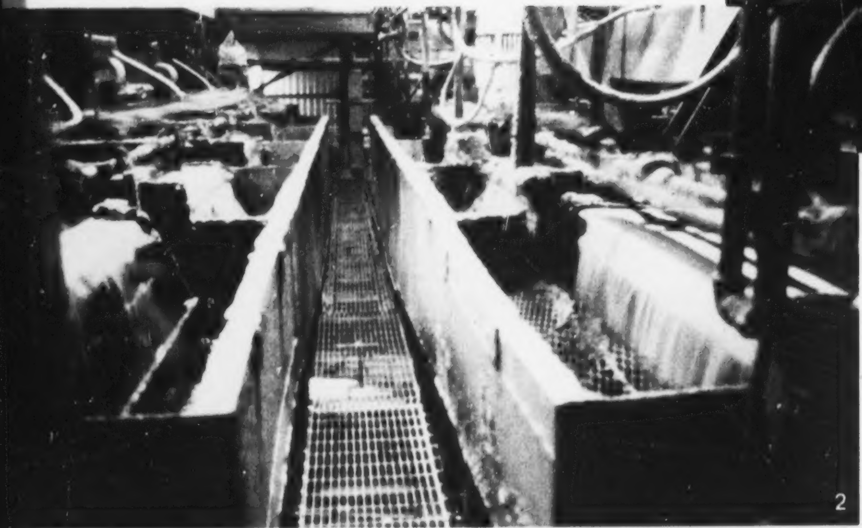
FC Report from Saskatchewan

SINCE the very beginning, the Saskatchewan potash industry has been . . . well, turbulent. The first company to try mining the richest known potash reserve in the world, Western Potash Corp., ran into technical and financial problems and abandoned the project. The second company, Potash Company of America, successfully opened its mine and refinery in November 1958 only to have seepage of water into the shaft force the closing of the mine just one year after the $20 million complex began production. The mine remained closed for 6 years until the problem was finally solved. The third company, International Minerals & Chemical, made a major technological breakthrough by buttoning up the Blairmore formation, a mass of fluid quicksand under explosive pressure "guarding" the ore deposit. (See page 22).

IMC opened the first of its two mines at Esterhazy in 1962. During the next three years, construction of 7 other mines began and by the end of the '60s, the Saskatchewan industry was producing over 8 million tons K_2O a year.

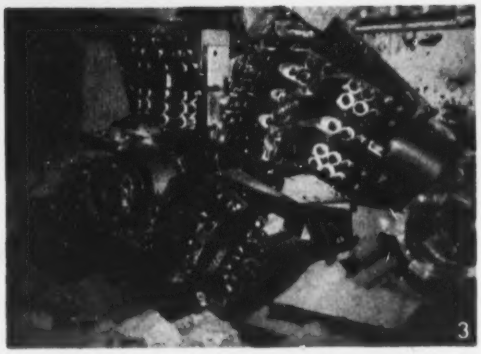
The growth was rapid, far more rapid than growth in demand, and prices plummeted. Charging that the reserves of a valuable mineral were being squandered at the expense of the people of Saskatchewan, the provincial government instituted a prorationing program, curtailing production to about 40% of rated capacity and establishing a minimum selling price. As demand increased, the various mines were allowed to increase production and by the mid-1970s were

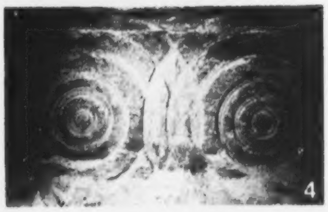




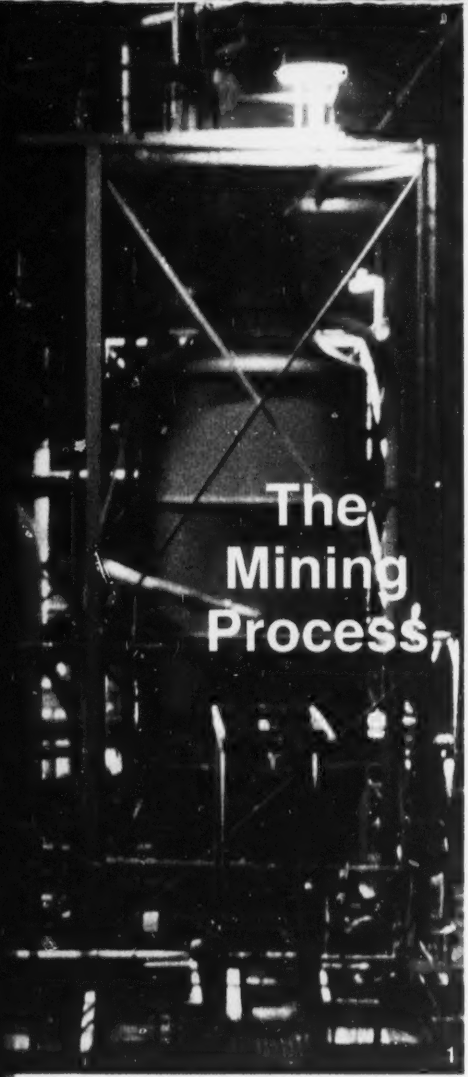
IN Saskatchewan, potash occurs in the Prairie Evaporite Formation in three beds which vary in depth from approximately 3000 to 5000 feet and more. Potash ore, or sylvinite as it is called, is a mixture of about 50% common salt (halite), 45% potassium chloride (sylvite), and 5% clay.

Of the 10 potash mines in Saskatchewan, 9 use conventional room-and-pillar mining techniques; Kalium Chemical at Belle Plaine extracts ore using a solution mining technique. In the conventional mining, the ore is extracted from the ore bed using high speed continuous mining machines that can cut from 8 to 12 tons of ore a minute. The ore is then broken into pieces, loaded on to a conveyor belt for transport to the shaft, then loaded





1. The refinery at Cory Division, PCS Mining.
2. Flotation cells in the refinery.
3. The continuous mining machine.
4. Distinctive pattern made by cutting edge of mining machine.



The Mining Process

1

into a skip for hoisting to the surface.

At the mill, the ore is first crushed, then introduced into a brine solution, and ground. Minute clay particles are removed by high agitation. After desliming, reagents are added to the brine to separate the potash from the salt by a flotation process. The potash particles are skimmed off the top of the flotation tank; the salt is drawn off from the bottom and then mixed with clay from the desliming step for disposal. In separate centrifuges, brine is removed from the recovered salt and potash and returned to the process. The salt is moved to the tailing pond, the potash conveyed to dryers. From the dryer the potash is screened into the four principal grades—granular, coarse, standard, and soluble.

Dust recovered from the drying step is dissolved in hot brine, then cooled under vacuum which causes the potash to precipitate out in white, highly pure crystals which are marketed in two grades: Refined potash is double crystallized and 99.9% pure KCl; soluble potash is 62.5% K_2O minimum. FC

operating at about 70% of rated capacity.

There were some grudging acknowledgements that the prorationing program had helped to stabilize the market; and if that had been the *only* government action taken during this period, Premier Ross Thatcher might well have gone down in industry annuals as a hero. But there were others.

In 1972 the government instituted a prorationing fee of $1 per K_2O ton, a year later doubling it to $2. That was onerous enough in the eyes of the 10 private producers until the new Premier, Allan Blakeney, announced his "Saskatchewan Potash Policy" in October 1974.

The policy included three programs, one of which was deferred: A reserve tax on the value of the potash ore reserves, mines, and refining facilities; *direct* participation by the provincial government in new projects and expansion of existing facilities; and payment in kind (*i.e.*, in potash) at a 10% discount of all taxes levied on the industry. Reportedly, the government planned to use this potash as the basis for forming a government marketing agency to launch the province into potash marketing. This segment of the program was deferred.

It was the reserve tax that exploded into a virtual war between the provincial government and industry. Industry figures showed that between the reserve tax and provincial mining charges and income tax, and the federal income tax, the industry was paying out almost 90% of its pre-tax profit. There were flat refusals to pay and lawsuits filed. (It was not until last year that the reserve tax issue was settled.)

The government counterattacked, claiming that the industry was not paying its fair share of taxes and ought, therefore, to be subject to additional imposts. Their premise? The province's potash reserves belong to the people of Saskatchewan. Premier Blakeney and his New Democratic Party were determined to see that "the maximum benefits of this rich resource go to the people."

To carry out the program of government participation proposed in the Saskatchewan Potash Policy, a crown corporation was formed—the Potash Corporation of Saskatchewan—in February 1975. Twenty months later PCS purchased Duval Corp.'s mine at Cory for $128.5 million. It was the first of five acquisitions made over the next two years.

PCS entered the market place with two strikes against it. Few people cottoned to the idea of government intervention in private industry. From major producers to the smallest of bulk blenders, the word was often, "We're not buying potash from those guys."

How PCS overcame that opposition to be considered to operate in a very responsible, statesmanlike manner is a story worth telling.

"Platform Decisions"

As a crown corporation, the PCS board of directors is made up of people in business, government, industry, labor, and agriculture. Chairman of the board is a minister-in-charge, currently the Honorable Roy Romanow, who reports to the provincial legislature. To head the fledging new corporation headquartered in Saskatoon, the board selected David Dombowsky, deputy minister of the Saskatchewan Department of Finance, and formed two wholly-owned operating subsidiaries—Potash Corporation of Saskatchewan Mining Limited and Potash Corporation of Saskatchewan Sales Limited.

Dombowsky, who had witnessed the confrontations between government and industry over the reserve tax, was acutely aware of the animosity toward PCS. Looking back, he points to what he terms "platform decisions that in retrospect have turned out to be very fortunate."

One such platform decision was the establishment of a sales office for North America at Atlanta, GA and the appointment of Jim Hunter (now retired) as manager of North American sales. Hunter was well known in the industry, had been vice-president of Duval Sales Corp., vice-president of Duval Corp. of Canada, and during this time was also vice-president of export sales and a director of Canpotex, the Canadian Potash Export Corp. Hunter assembled a team of veterans, several of whom had been with Duval, and who were equally well regarded by their associates in private industry.

Rolf H. Holzkaemper, managing director of Potash Corporation of Saskatchewan Sales Limited who joined

LISTEN to mining engineers discuss expansion of a potash mine and you'll hear some new jargon, shorthand phrases like Phase I and Phase II. What are they talking about?

Phase I means to bring an existing mine to its mill limit, and is usually essentially a debottlenecking.

Phase II brings the mine to its shaft limit, and generally requires construction of a new mill.

Phase III involves the addition of at least one new shaft.

Phase IV? That's a whole new mine!

David Dombowsky, president of Potash Corporation of Saskatchewan, is guiding the 10-year, $2½ billion expansion program.

Rolf H. Holzkaemper, managing director of PCS Sales, predicts "there'll be more discussion of allocation than trying to make a sale within a couple of years."

the company in 1978 from Potash Company of Canada (Potacan), was a competitor during those early days of PCS so that his evaluation could be considered as unbiased.

"PCS took a right first step in hiring Hunter, Tom Tucker, and the rest of the men who formed the nucleus of the marketing team. Much of the credit for the company's acceptance is due to their personal acceptability in the field."

Another platform decision, Dombowsky believes, was to become an active part of the industry. "We took the decision that we wish to cooperate with other producers in the area of masket development. Very early on we joined the Potash and Phosphate Institute and are now the single largest contributor to PPI, which is American-based. We became members of The Fertilizer Institute and the International Potash Institute. We have been major contributors, not only in terms of money but also in terms of leadership and ideas, in all three organizations."

A third was the decision to go into the private money market to finance acquisitions, and to pay taxes in the same manner as a private company. A fourth, and perhaps in retrospect one of the most important, was the decision "to launch expansions at our mines when there was a surplus of product on the market."

Dombowsky points out that PCS bought a number of operations "when there was a surplus of product, when the prices were depressed and we had a breakeven position in rate of return. A lot of forces around us were threatening. But the board stuck with us, and we think it has worked out well."

For the year ended June 30, 1977, PCS reported sales of $22 million; for '78, $107 million; for '79, $210 million; for 1980, $312 million. The outlook for '81 (when PCS goes on a calendar year for fiscal reporting) is for "a substantial increase."

Production has grown during this same period from 820,000 tons KCl to 4.75 million in '79–80. And PCS recently unveiled a 10-year plan to increase production to 12½ million product tons by 1990.

Today PCS accounts for about 40% of total Saskatchewan production. There has been a constant upgrading of production facilities since the corporation acquired its first mine in 1976. There was a period during prorationing and the reserve tax when very little money was invested in any of the mines, in some instances only bare necessity maintenance work was completed. Even when demand boomed in '77, most of the mines were incapable of operating at rated capacity. Debottlenecking was the first order of business.

That challenge fell to Donald G. Matheson and Brian C. Kaukinen. Matheson, now vice-president—technical for PCS, joined the company in 1975 from Comstock International Limited where he was general manager of the mining division in the special projects group. Kaukinen joined PCS Mining that same year as vice-president of production, leaving Hudson Bay Mining and Smelting. He is now operating director of PCS Mining.

"In most instances the management of the various mines stayed when PCS acquired the operations. All the mines used basically the same techniques but there were individual differences—not only in ore body but in organization and psychology of operating," Kaukinen explains. "We have steadily improved all the mines, and to some extent have taken ideas for better organization and operation from one mine and introduced them to the others. There is still a great deal of autonomy of operation at each of our mining divisions."

There are several reasons for having each division operate as a profit and loss center, perhaps the most paramount being "to prevent any decay of competitive spirit between the plants that existed before PCS acquired them." As Don Matheson explains, "We haven't introduced change for the sake of change. We have tried to stress pragmatic values."

The first mine to be acquired was the Duval operation at Cory. "Because this is the operation we know best, it has had more influence on the rest of our divisions," Kaukinen believes. "But each of our five mines is still unique in many aspects."

When PCS took over at Cory, rated capacity was 1.2 million tons KCl/year. Debottlenecking has upped capacity by 300,000 tons. "We have added a mining unit, expanded underground storage, and increased the speed of the hoist," Kaukinen explains. "The cost was just about $7½ million."

Rocanville was the second acquisition, purchased from Hudson Bay Mining & Smelting. Capacity was upped from 1.2 to 1.4 million tons KCl by adding more compacting and screening area, increasing storage on surface, and debottlenecking in the mill. Cost of this Phase I improvement was $11½ million. Product split was also altered, with more coarse and granular being produced.

Canadian Potash Industry Expansions

SASKATCHEWAN

Central Canada Potash

Expansion: Increasing capacity to 1.14 million tons/year KCl

In Production:

Cost: $72 million

Cominco

Expansion: Upgrading shaft and mill to increase capacity to 1.1 million tonnes/year

In Production: 1982

Cost: $30 million

Kalium

Expansion: Refinery improvements to increase capacity to 1.8 million tonnes/year

In Production:

Cost: $23 million

Potash Company of America (PCA)

Expansion: Improve and upgrade surface facilities to increase capacity to 1 million tons/year.

In Production: 1982

Cost: $23 million

Potash Corporation of Saskatchewan (PCS)

Bredenbury

New mine: Shaft construction to begin in 1982. Capacity projected at 3.6 million tons/year of product.

In Production: Late 1986

Cost: $600 million

Lanigan

Expansion: Adding 10 mining machines and related equipment to increase production to 3.2 million tons

In Production: 1983

Cost: $430 million

Rocanville

Expansion: Adding mining equipment and milling capacity to increase production to 2.0 million tons/year

In Production: Late 1981

Cost: $73 million

NEW BRUNSWICK

Denison-Potacan Potash Co.

New mine: Shaft construction underway. Initial production estimated at 1.3–1.5 million tons/year.

In Production: Spring 1983

Cost:

Potash Company of America (PCA)

New mine: Surface facilities now under construction. Rated capacity will be 1 million tons/year

In Production: Late 1982, early 1983

Cost:

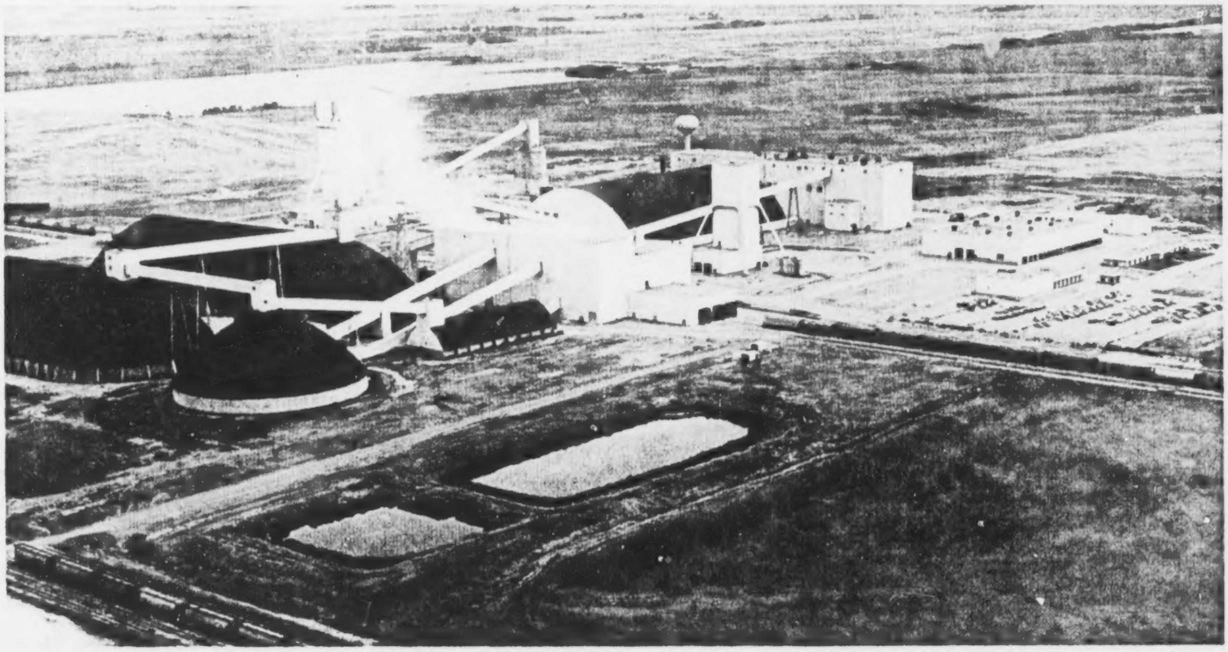
British Petroleum of Canada

Has been granted exploration rights

MANITOBA

International Minerals & Chemical (IMC)

$2 million exploration program now underway. No production anticipated within decade.



Don Matheson is vice-president—technical for PCS.

Late this year Phase II will be completed at Rocanville. Mining equipment has been added, and milling capacity increased to bring rated capacity to 2.0 million tons/year. "We are essentially increasing the entire concentrator complex by 50%," explains Kaukinen. "Enough compaction capacity will be added so that all of the incremental production can be coarse or granular grades. About $10 million of the $72 million budgeted for the expansion is being spent underground, most of it for two new four-rotor mining machines. The conveyor system is being expanded and the skip capacity boosted."

In late 1977 PCS acquired Lanigan from Alwinsal Potash. Capacity was rated at 1 million tons "but it had never been reached. We shut down Lanigan for more than five months to complete refurbishing. Since then a new changehouse has been built, underground mining machines have been overhauled, and we've added a second shaft," Matheson points out. "We're now going into Phase II which includes a fleet of 10 new four-rotor continuous borer mining machines to develop two new mining blocks underground. We plan to introduce a new mining configuration when the machines come on stream. A new mill will be built. When Phase II is completed, Lanigan Division will have a rated capacity of 3.2 million tons KCl per year. That will make it the largest single-production-shaft potash operation in the world."

Jim Sadler is vice-president of engineering for PCS.

Operating director for PCS Mining is Brian Kaukinen.

Vice-president of corporate development for PCS is Doug Karvonen.

Last of the mines to be acquired was Allan, in which PCS holds 60% ownership, Texasgulf 40%. Last year PCS Mining became operator of the mine, with Texasgulf retaining its interest in the assets of the mine. A Phase I expansion is now underway which will add 240,000 product tons to current production. Additional equipment is being installed in the mill, some modifications being made in the underground conveyor system, and the hoist speed increased.

PCS' investments also include $1.3 million to construct a potassium sulfate pilot plant in Saskatoon to "prove the production process which, if successful, could lead to a plant that in 2 to 3 years will be capable of producing 200,000 product tons of potassium sulfate."

There is a strong emphasis on research and development. David Dombowsky points with pride to the decision to return a minimum of 1½% of total gross sales to R&D. PCS is building a new research facility at SEDCO Center in Saskatoon. The R&D program is aimed at developing new products, lowering production costs, and improving existing product quality, as well as agronomic research. "We take our role in world agronomy very seriously," Dombowsky emphasizes. "In fact, I feel very strongly that not enough is being done, and it is one of my own priorities as well as a priority of the corporation."

"We will have a full agronomy department sometime this summer to support our sales efforts in the field," adds Holzkaemper. In addition, PCS is supporting research at the university level.

But it is in the area of production and recovery that PCS will be concentrating much of its R&D efforts. Heading up the program are Matheson, Kaukinen, and James F. Sadler, who joined PCS last year as vice-president of engineering. A graduate of the Royal School of Mines in London, England, Sadler has more than 30 years of diversified Canadian mining experience, including 14 years in potash manage-

Gene Stockert is manager of national accounts (co-ops) for PCS Sales.

Doug Logsdall is manager of national accounts for PCS Sales.

Sid Blair is executive assistant to Rolf Holzkaemper, managing director of PCS Sales.

Manager of field sales for PCS Sales is Tom Tucker, headquartered in Atlanta, GA.

Steve Dechka is special assistant to the managing director of PCS Sales.

ment positions. His last position was at Allan Potash Mines where he was president and general manager. Sadler will also be responsible for the $2.5 billion expansion program outlined in PCS's 10-year plan.

"We'll be investigating new drying processes, alternative methods of salt separation, improved mining techniques to increase extraction methods, ways of increasing the recovery percentage of potash from ore, and techniques and methods for reducing environmental impact," explains Matheson.

The Potash Industry's "Albatross"

The phosphate rock industry has gypsum as its albatross, the potash industry salt. There is a ratio of roughly 4 to 1 on ore raised to the surface to potash recovered, and that's with recovery of 90% of the potash contained. The rest is common salt and clay. Giant salt piles can be found adjacent to every mining location. To date, all storage has been above ground although there has been some speculation that storage underground might be proposed in the future as backfill. This would solve an environmental problem, but getting the salt back underground is a problem because it can't be slurried. The salt would have to be bone dry to be used even as blown-in fill. Another possibility might be to move the milling underground, which would also save the cost of hoisting the salt and clay to the surface. The stumbling block here is that concentration of potash from the ore is a very wet process, and introducing water into the mine could be disastrous. The potash is buried in salt, and salt is hygroscopic. Excessive moisture would cause both the salt and the potash to dissolve.

Jim Sadler calls the technique of tailings impoundment "a difficult one." Projects are being planned to see what the weight of salt piles is doing, if there is any sinking, so fail safe dyking systems can be developed. "This is not an intense environmental issue but it could be in the future," acknowledges Matheson. "If we have to go underground to store the salt, it would kill the industry from a cost standpoint."

Sadler points out that PCS is also looking at energy consumption at the mills, and hopes to replace natural gas with local Saskatchewan coal. "It's just a question of how and when we're going to use it," emphasizes Matheson. "When the industry started in the '60s, natural gas cost 25 cents per mcf; now it is approaching $2."

Reducing mining and refining costs are being given top priority. Sadler admits that there are few new techniques that have been developed. With the exception of continuous mining

For Details Circle No. 109 on Postcard——>

machines adapted by IMC from the coal industry, the mines in Saskatchewan are based on methods long used at Carlsbad, NM. "There have been relatively few significant breakthroughs in potash mining technology," he acknowledges. "It's no big deal to duplicate what you've got. We have to innovate."

One innovation is planned for Lanigan. Potash miners employ a technique called room and pillar. This involves cutting a series of rooms which are separated by pillars. A room 67 feet wide and 4000 feet long is cut by the four-rotor continuous mining machine. A pillar 50 to 60 feet wide is left and another room 67 feet wide and 4000 feet long is cut. Then a second pillar 180 feet wide is left. The same series is then repeated. Lanigan will switch to a four-pass system. A room 8 feet high and 45 feet wide will be taken out in two passes, and then the room will be deepened another 7 feet in two additional passes. Sadler explains. "We've been leaving a lot of ore in the floor up until now. Besides giving us more ore, the new system of mining will prevent bad floor heaves associated with the ore that we leave behind."

Mine layout and experiments in room and pillar designs are continuously being studied. Each mine is routinely shut down one day a week for maintenance of equipment and to plan future moves. A laser beam is used to maintain direction of the mining machine.

First Grassroots Mine

Last fall fieldwork began on PCS's first grassroots project—a mine and refinery to be built near Bredenbury. "We have to complete an environmental impact study before final approval for plant construction is granted by the provincial Department of the Environment," explains Matheson. The EIS is expected to be completed within a year.

"Work will concentrate on studies of the ground and surface water conditions, and environmental impact on the region's plant and animal life. We will also have to drill exploration holes to more accurately assess the area's ore grade, the outside limits of the ore body, and the most suitable location for shaft construction," adds Douglas A. Karvonen, vice-president of corporate development.

Pending approval by the Department of Environment, shaft construction is scheduled to begin in 1982 and will take about 4 years to complete.

The plant is expected to come on stream by 1986 with an annual capacity of 3.6 million short tons KCl. When fully operational, the facility will employ more than 400 people. Cost of the project will exceed $600 million.

Completion of Bredenbury and expansion currently underway and planned will push PCS's production to 12½ million product tons by the end of the decade.

While PCS Mining was debottlenecking the minesites, PCS Sales was beginning to turn animosity into respect, and gaining a considerable acceptance in the market place at the same time. One PCS salesman who was among the first in the field recalls it was an uphill battle in the beginning. "Our competitors weren't too happy about what was happening in Saskatchewan and their criticism was expressed throughout the U.S. market, even unwarranted personal criticism. It took fortitude and a determined sales approach but we slowly gained a significant foothold in the market place.

"Another thing that helped was our shipping performance. Because we had more than one source of supply, we could deliver the product."

Knowledgeable salesmen, service, and dependable delivery have been the foundation on which PCS Sales has built an enviable sales record. Today there are 12 district managers calling on some 1200 individual, independent field accounts in the U.S. Head of field sales is Tom Tucker, a Duval veteran who joined PCS in 1977. Gene Stockert is manager of co-op accounts, while Doug Logsdail is manager of national accounts. Tucker heads the sales office in Atlanta, GA;

Conquering

IT happened almost two decades ago but without the conquering of the Blairmore the rich reserves of potash that bless Saskatchewan might never have been fully developed.

Potash was first discovered in southeast Saskatchewan in 1943 when geologists looking for oil discovered evidence of the world's largest known body of high grade potash. The ore body stretches 450 miles across Saskatchewan into Manitoba, and in some areas is 50 miles wide, with the ore beds 3000 to 5000 feet below the earth.

Guarding the ore was a formation that almost defied mining engineers. Called the Blairmore, it is a mass of fluid quicksand under explosive pressures over 200 feet thick which begins at the 1200-foot level within the some 2700 feet of shale and limestone that covers the potash ore body. Pressures in the Blairmore run as high as 475 psi. "To puncture the Blairmore is to release the fury of forces imprisoned for 200 million years," observed International Minerals & Chemical Corp., the first company to successfully conquer the Blairmore.

IMC had been exploring the potential of the Saskatchewan reserves and after much deliberation decided to sink a shaft near Esterhazy. Work began in 1957. A year later the concrete-lined shaft had been pushed to a depth of 1200 feet, just above the Blairmore. To reach the potash the quicksand had to be tunneled through, the high pressure waters contained. IMC graphically described the problem in a special potash report as follows:

"There are two primary ways to control underground water. Pipes can be sunk into the water-bearing formation and refrigerants circulated through them to freeze it. Then digging can proceed through the frozen formation. Shaft walls are lined as you go, before thawing is permitted.

"Grouting is the other method. Deep holes are drilled into the bottom of the shaft. When these holes hit water, a mixture of water and cement is pumped down under heavy pressure. The pressure forces the grout into water-bearing porous rock and cracks between rock. The grout hardens and seals off the water.

"At first grouting was employed but the Blairmore counterattacked. Twice it struck back, shooting water into the shaft and endangering the whole project. Once the flood surged to within 120 feet of the top of the shaft."

IMC decided to try a technique never before used in North America but tried and proven in Europe. First step was to freeze the Blairmore. "Sixty-two freeze holes were drilled into the stratum," IMC noted. "Pipes in the freeze

the Blairmore

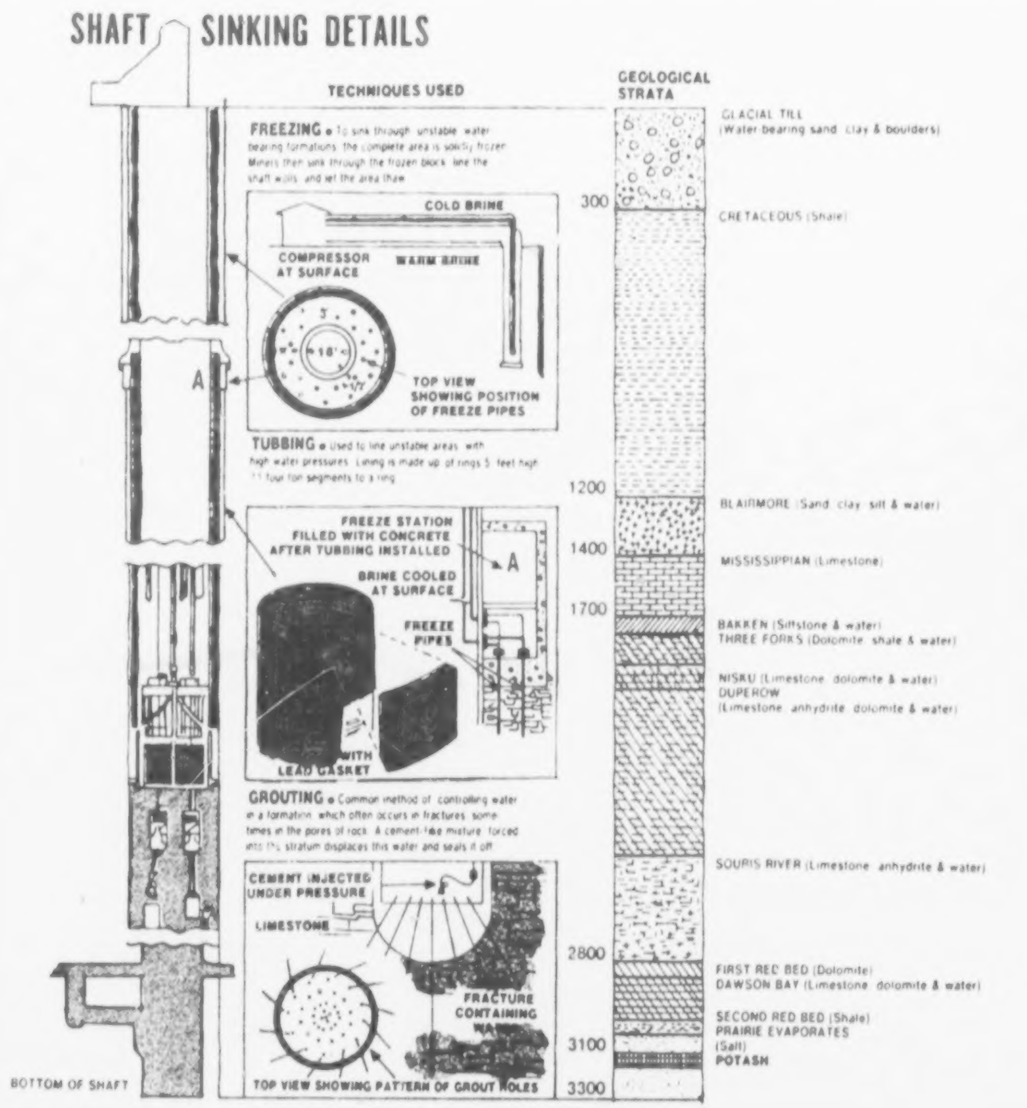
holes circulated a brine solution pumped in at a frigid 30° below zero. The Blairmore began to ice up, expanded, and froze. Freeze pipes burst. They were replaced. But now the Blairmore contained pockets of brine from the burst pipes, brine that had to be frozen along with the Blairmore water. This required a special refrigerant, and for a year a lithium chloride brine at −60°F coursed through the stubborn Blairmore until finally its treacherous quicksands were one great frozen mass—a 3 million cubic-foot ice cube.

"Now the shaft sinkers went to work. Explosives could not be used to blast loose the frozen sand; the shock could break the freeze pipes or rupture the vertical cylinder of ice that had been so precariously formed. So every 5 feet, 11 4-ton segments of tubbing (cast-iron casing in curved segments) were lowered, one by one, and placed into position. Thick lead gaskets were installed between segments and the tubbing bolted together to form a water-tight barrier. Foot by foot the job proceeded—through the 200 feet of Blairmore, and for a total of 150 feet above and below it."

76 rings of tubbing (each 5 feet deep) were installed, almost 7 million pounds of iron held together by 17,000 giant bolts. To insure a water-tight lining, miners pounded a total of 45,000 wooden wedges into place at three selected spots between the shaft wall and special tubbing rings. The wedges ranged in size from big circus tent pegs to almost toothpicks. They formed a mass so dense that not even a steel pike could be driven into it.

IMC had successfully "buttoned up" the Blairmore, and proved that the potash could be mined. The rest is history.

FC



SHAFT SINKING DETAILS
TECHNIQUES USED
GEOLOGICAL STRATA
COLD BRINE
COMPRESSOR AT SURFACE
WARM BRINE
3'
18'
1/2'
TOP VIEW SHOWING POSITION OF FREEZE PIPES
A
FREEZE STATION FILLED WITH CONCRETE AFTER TUBBING INSTALLED
BRINE COOLED AT SURFACE
FREEZE PIPES
WITH LEAD GASKET
CEMENT INJECTED UNDER PRESSURE
LIMESTONE
FRACTURE CONTAINING WATER
TOP VIEW SHOWING PATTERN OF GROUT HOLES
BOTTOM OF SHAFT
300
1200
1400
1700
2800
3100
3300
GLACIAL TILL (Water bearing sand clay & boulders)
CRETACEOUS (Shale)
BLAIRMORE (Sand clay silt & water)
MISSISSIPPIAN (Limestone)
BAKKEN (Siltstone & water)
THREE FORKS (Dolomite shale & water)
NISKU (Limestone dolomite & water)
DUPEROW (Limestone anhydrite dolomite & water)
SOURIS RIVER (Limestone anhydrite & water)
FIRST RED BED (Dolomite)
DAWSON BAY (Limestone dolomite & water)
SECOND RED BED (Shale)
PRAIRIE EVAPORATES (Salt)
POTASH

FREEZING • To sink through unstable water bearing formations the complete area is solidly frozen. Miners then sink through the frozen block, line the shaft walls, and let the area thaw.

TUBBING • Used to line unstable areas with high water pressures. Lining is made up of rings 5 feet high, 11 four ton segments to a ring.

GROUTING • Common method of controlling water in a formation which often occurs in fractures, sometimes in the pores of rock. A cement-like mixture forced into the stratum displaces this water and seals it off.

WORLD POTASH SUPPLY
(Million Tonnes K_2O)

	1975/76	1978/79	1979/80	1985/86	1990/91	1980/91 Increase
East Europe	11.0	11.5	10.0	15.3	19.0	9.0
North America	7.1	8.5	9.4	13.3	15.6	6.2
West Europe	4.4	5.3	5.7	6.1	6.1	.4
Asia	.7	.7	.8	1.9	2.3	1.5
Africa	.2	—	—	—	—	—
Latin America	—	—	—	.3	.5	.5
World Total	23.4	26.0	25.9	36.9	43.5	17.6%

TOTAL WORLD DEMAND
(Million Tonnes K_2O)

	1978/79	1979/80	1980/81	1981/82	1985/86	1990/91
North America	6.7	6.8	7.2	7.4	8.4	9.7
West Europe	5.8	5.9	6.1	6.3	6.9	7.6
East Europe	9.4	8.8	10.2	10.8	11.9	15.1
Latin America	1.6	1.7	1.8	1.9	2.5	3.3
Asia	2.7	3.0	3.1	3.3	4.1	5.4
Africa	.4	.4	.5	.5	.6	.8
Oceania	.3	.3	.3	.3	.3	.4
Total Demand	26.9	26.9	29.2	30.5	34.7	42.3

Source: PCS

Stockert and Logsdail work out of the head office in Saskatoon. Both are veteran fertilizer men. Logsdail joined PCS in 1979 from Terra; Stockert came from CF Industries last year.

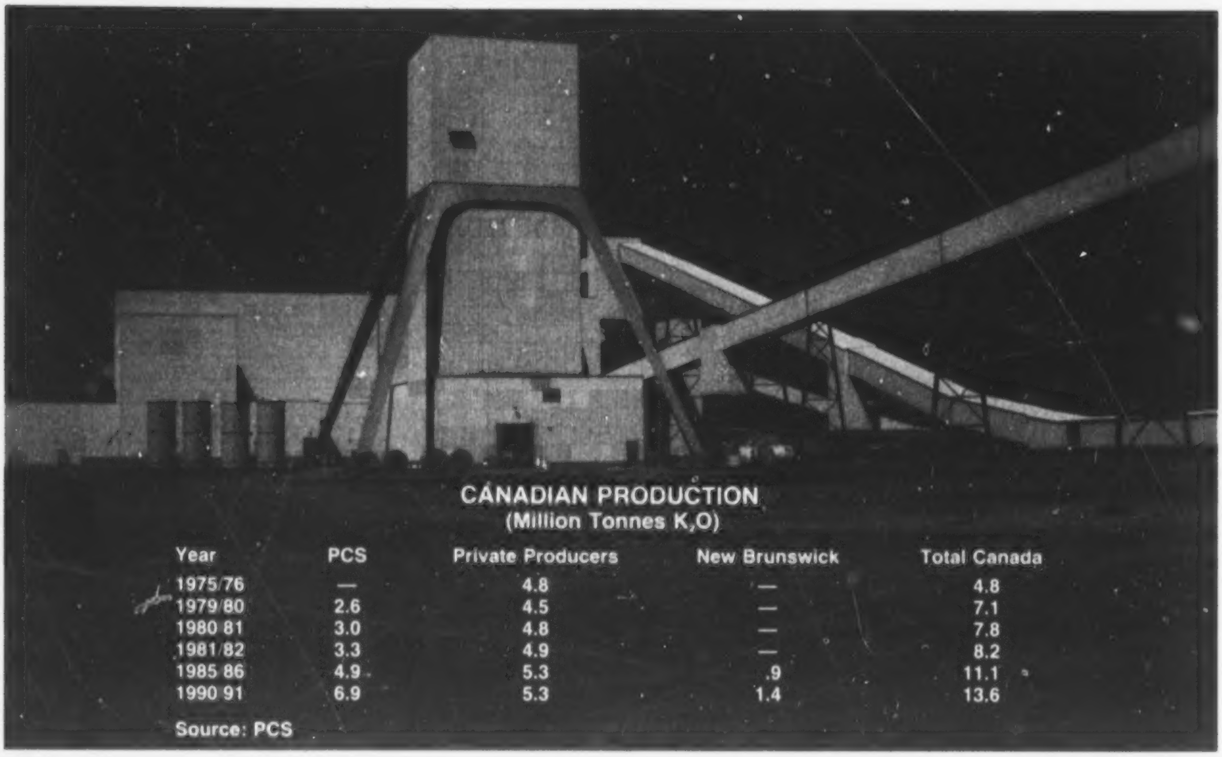
"About 55% of our sales are to the U.S., 5% in the Canadian market, and 40% goes into international markets through Canpotex," explains Rolf Holzkaemper. "Co-ops and national accounts make up about 65% of our North American sales.

"We've gained share of market more rapidly than expected," he adds, "particularly in 1979–80 when our total sales reached 4.6 million tons KCl. As a result we have speeded up some of our expansion plans.

Holzkaemper, called by one industry observer "the smartest marketer in the potash business," thinks the gains in market share have been hastened "by having professional people who acted in the market place in a responsible manner."

The field staff is a veteran one, with an average experience in the fertilizer market of 12 years. As Tom Tucker points out, "The confidence of people in our salesmen was really the turning point. They knew our men and they believed in them."

It didn't hurt that PCS was able to deliver product (it's an advantage when you can ship from five different production sites). "We were recognized as a very dependable shipper," Holzkaemper notes with considerable pride. "And we've invested considerable



CANADIAN PRODUCTION
(Million Tonnes K_2O)

Year	PCS	Private Producers	New Brunswick	Total Canada
1975/76	—	4.8	—	4.8
1979/80	2.6	4.5	—	7.1
1980/81	3.0	4.8	—	7.8
1981/82	3.3	4.9	—	8.2
1985/86	4.9	5.3	.9	11.1
1990/91	6.9	5.3	1.4	13.6

Source: PCS

capital in trying to develop the best delivery service possible."

Today PCS operates in excess of 1400 company-owned or leased railcars, according to Bud Foley, head of transport operations for PCS Sales. Last year the company initiated the first unit train to move direct from the mine to warehouses in the Midwest. (IMC operates unit trains from the U.S. border, but product is shipped from Esterhazy to the border by truck.)

Potash centers have been established at four locations: Danville, Seneca, and Springfield, IL, and Waterloo, IA. Trains are loaded at the mine and unloaded at the potash centers within 24 hours of arrival. "We have a 7- to 8-day cycle from minesite to potash center and return," Foley points out. "This compares with an average turnaround of 35 to 40 days for single car deliveries. It took less than 3 days for the first unit train to move from Rocanville to Waterloo."

Each potash center is equipped for fast loading of trucks "to minimize delays and provide the best possible service to customers." The centers vary from 40,000 to 60,000 tons in storage capacity.

David Dombowsky calls development of the transportation system one of the milestones in the corporation's short history. "We took over operations at several mines during a rough railcar shortage. Sometimes we could only get a couple of cars a week. Here we were, sitting on all that product and we couldn't get railcars. We went to work and with a very short lead time built up a fleet of our own cars, got some warehouses under lease, and then started the unit train.

"We don't spend as much time now on domestic transportation as we did in the early days," he adds with a satisfied grin.

Holzkaemper, considers the potash centers a viable solution to smoothing out shipping problems in areas of concentrated use. "It takes a sizable number of tons to make a center feasible," he explains.

"Pricing out of the centers is calculated to equate with single car shipment from the mines, and there is a trucking allowance. All product moves from the center by truck."

The concept of the potash centers took some selling, though. As Tucker explains, "A lot of the smaller dealers are not set up to take truck delivery. We had to persuade them that it could be done using a payloader. They're beginning to adapt and they're finding that they like the system. Many of them are starting to work out backhauls. A 50–60 mile trucking range from the center we've found is reasonable as far as our dealers are concerned."

PCS sees the concept of potash centers as a possible answer in areas where rail abandonment is disrupting normal movement by railcar. Another advantage is becoming evident in these days of high interest rates. "Dealers are holding back, waiting until closer to season before filling up. With the centers, we should be able to fill those later-than-usual orders without delay."

Holzkaemper looks for potash supply/demand to be in balance this spring, with some possible local shortages. But looking ahead a couple of years, he confidently predicts, "We'll be talking more about allocation than trying to force a sale." This despite the fact that all Saskatchewan producers are expanding or have announced expansion plans, plus two new mines are being built at New Brunswick by Potash Company of America and Denison/Potacan, which when completed, will add in excess of 2 million product tons.

In a talk at the ISMA Mid-Year Conference held in Tampa, FL in mid-November, Holzkaemper predicted that "Supply and demand will be very close throughout the period under review (1980–1990)."

Looking at world potash supply, he noted that "We envisage availability to grow from 25.9 million metric tons K_2O last year to 36.9 million metric tons in 1985/86 and to 43.5 million metric tons in 1990–91. The possibilities of minor delays in implementing the expansions always exist; we cannot envisage, however, major production anywhere beyond the levels projected. (See Table 1 on page 26).

"Demand totaled 26.9 million metric tons K_2O in 1978–79 and again in 1979–80. Based on the apparent strong

How PCS Was Organized

A provincial crown corporation, Potash Corporation of Saskatchewan was established in February 1975. Its two wholly-owned subsidiaries, Potash Corporation of Saskatchewan Mining Limited and Potash Corporation of Saskatchewan Sales Limited, were incorporated in October 1976 when PCS made its first acquisition. PCS Mining is now divided into five divisions:

Cory

Established in October 1976 with the acquisition of the Duval mine at a cost of $128.5 million. Rated capacity of 1.2 million tons KCl/year has been increased to 1.5 million tons by debottling. Cost: $7.8 million.

Rocanville

Established in April 1977 with the purchase of Hudson Bay Mining & Smelting mine at a cost of $144 million. Phase I expansion increased capacity from 1.2 million tons KCl to 1.4 million at a cost of $11.5 million. Phase II expansion now underway will raise capacity to 2.0 million tons. Cost: $73 million.

Lanigan

Established in November 1977 with purchase of Alwinsal Potash mine at a cost of $76.5 million (plus former owner's liability for reserve tax of $9 million). Expansion and refurbishing at cost of $40 million raised capacity to 1.5 million tons KCl. Phase II expansion now underway will increase capacity to 3.2 million tons KCl. Cost: $400 million.

Esterhazy

Established in February 1978 with purchase of potash assets of Amax Potash Ltd. for $85 million. Assets included a portion of International Minerals & Chemical's reserves (estimated to be equivalent to 90 million tons KCl) and a long-term service agreement with IMC for production and processing.

Allan

Established in April 1978 with purchase of 60% interest held by U.S. Borax and Swift at a cost of $85.8 million. (Texasgulf retains its 40% interest). Rated capacity is 1.5 million tons KCl/year.

movement of potash so far this season, and a recovery in Soviet potash production and consumption to previous levels, we project an increase of 8.4% in the current year and a further 4.5% increase in 1981–82. By 1985–86, our analysis projects world demand of 34.7 million metric tons, to grow to 42.3 million metric tons by 1990–91." (See Table 2 on page 26).

If Holzkaemper's projections are correct, supply will exceed demand at the end of this decade by a scant million metric tons.

Could PCS and other producers be overestimating the market, with the expansion programs turning into overexpansion? David Dombowsky doesn't believe so. "There is always a good and a bad scenario. We're trying to read the market as carefully as we can and avoid as many pitfalls as we can. We know that we're going to make mistakes because producers have always made mistakes in gauging the market, but I do think this: the 1980s are not the '70s. Inflation is rampant, capital formation is difficult. I don't think the '80s will be characterized so much by overproduction as by underproduction."

As the largest supplier of material to Canpotex (and likely to continue so for the future), PCS is looking far beyond the borders of North America. Holzkaemper and Steve Dechka, his special assistant in the area of international markets, will be visiting important potash customers throughout the world on a regular basis.

"We expect that 60% of our potash will be sold overseas through Canpotex by the mid-1980s," Holzkaemper explains. "We hope to expand our agronomy program to include other areas of the world in support of the research programs being conducted by International Potash Institute."

That's not to say that PCS will be ignoring the North American market. Holzkaemper and his associates look for North American demand to grow from 6.8 million metric tons K_2O last year to 9.7 million metric tons by 1990–91. In his talk at ISMA, Holzkaemper declared: "North America is, and will continue to be, a significant supplier of food and feed grains to the world. The market outlook is firm in the short term; as stated, I project a 6–7% growth this year, following two years of nearly even movement. The forecast for North American demand is, all in all, conservative and may well be exceeded."

Broaden into N & P?

Holzkaemper restricted his projections to potash, but there is no secret that PCS is anxious to broaden out into nitrogen or phosphate, or possibly both.

Last year PCS joined with Agrico Chemical on a feasibility study to determine the economic viability of establishing fertilizer manufacturing facilities in Saskatchewan, assessing "the potential markets, plant sizes, and investment costs for manufacturing nitrogen and phosphate-based products." As Dombowsky pointed out in announcing the study, "Should the feasibility study result in decisions leading to manufacturing facilities in Saskatchewan, the Corporation would be in an excellent position to ensure a long-term supply of fertilizers for Saskatchewan farmers."

In another study, PCS joined with Ocelot Industries, a Canadian-based oil and gas exploration company to jointly investigate the possibility of producing ammonia and nitrogen-based fertilizers in Saskatchewan. Capital costs, markets, raw materials requirements, and site location are among the issues that will be addressed.

No conclusions have been reached yet on either study, but odds are that PCS will be producing ammonia and mixed fertilizers with the companies involved in the study, some other partner, or on its own. A possible partnership of Agrico-PCS in developing Agrico's phosphate rock reserves in North Carolina is also being rumored around the industry.

Dombowsky will only admit that PCS "is studying reserves in a variety of places, including North Carolina. But there's absolutely no commitment . . . and that's not the *only* source."

Speaking from what he called "an admittedly biased position," Dombowsky discussed the stability of today's potash industry compared with the situation of just a half-dozen years ago. "A number of things have happened to bring stability to the market place in terms of prices and supply. First of all, no one judged that world supply/demand would come together as quickly as it did. The Chinese came on with some fairly large orders, a mine went down in the Congo, and we took the opportunity of long supply to shut down one of our operations to refurbish it. The combined effect of these things heightened the demand.

"I would like to add this comment," he continues. "From the time we bought our first mine we had expansion in mind. And you'll note that we started expanding production capability immediately. This was a pretty courageous position on the part of our board because prices were low, cash flow was minimal, and we were already spending capital for additional acquisitions. As it turns out this was fortunate for the entire industry. No one else was investing money in Saskatchewan potash at that time; now all of us are pumping up production as quickly as we can. Without that headstart from PCS on expansion, shortages could be serious." **FC**

MARCH • 1981

FARM CHEMICALS

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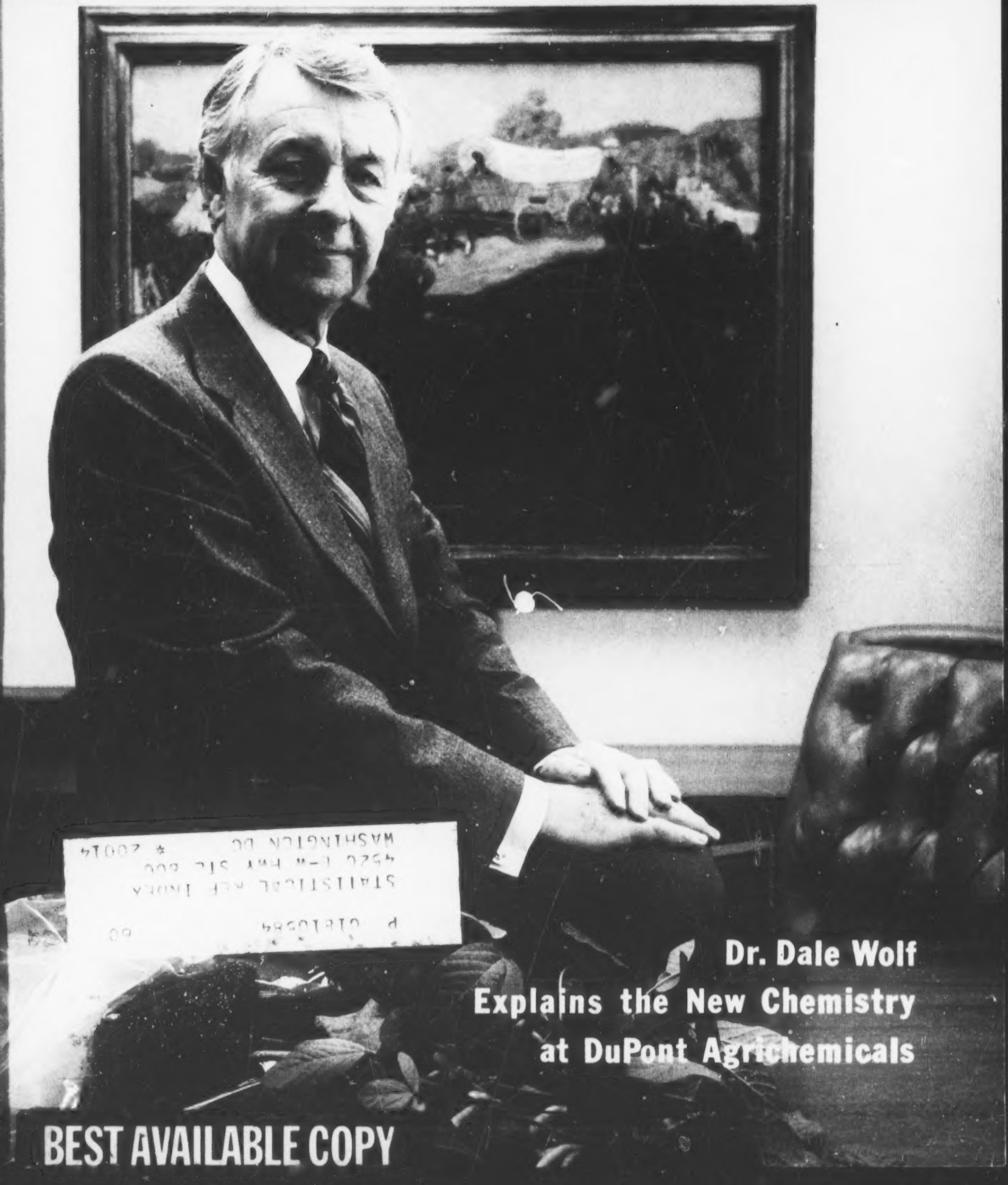

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**Dr. Dale Wolf
Explains the New Chemistry
at DuPont Agrichemicals**

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FARM CHEMICALS

Vol. 144 No. 3 March 1981

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THE COVER STORY

Although DuPont is known as a company with a broad line of pesticides, a large share of its most notable successes have been in herbicides. A good example is its new sulfonyl urea weed killer "Glean" which is targeted for wheat. Little wonder for DuPont's record in herbicides, however, when you realize that the company's vice president and head of the biochemicals department was the first to receive a PhD degree in weed control. Dr. Dale E. Wolf also wrote one of the original texts on the subject. The DuPont Agrichemicals story starts on page 13.

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A Barn-Burning Fertilizer Year!

That's what industry leaders were predicting as TFI held its annual conference. Will consumption really reach 56.5 million tons? It may all depend on the weather—and the transportation system.

IT was downright cold, with temperatures hovering below zero and sharp winds coming off Lake Michigan—just the kind of weather fertilizer people have come to expect when The Fertilizer Institute holds its annual meeting each year in Chicago in February. Still, the sun shone brightly, reflecting the mood of the some 1100 industry leaders who crowded the lobby and corridors of the Hyatt Regency.

Almost without exception, they're looking for 1980–81 to be a barn-burning year despite drought conditions in some major cropping areas. TFI President Ed Wheeler, who has held steadfastly to his projection of 55 million tons, confidently predicted use could soar to 56.5 million tons if weather conditions improve.

In fact, the worry isn't so much over sales but how to get the product to market. With the Mississippi River dropping almost daily, there is grave concern about barge movement of fertilizer materials. It's going to be a rail movement year, complicated by the reluctance of some dealers to fill up early because of high interest rates. In his "state of the union" address, Wheeler warned that "Placing a booming load of orders on the railroads without much prior notice could well lead to chaos. This is the single greatest concern we all ought to have. We can't do anything about the weather. We *can* do a great deal about transport if we act now—today. I urge all of you to give this matter your greatest and immediate personal concern."

Then Wheeler shifted to rising costs, noting that "energy, transportation, and plant maintenance costs in particular have continued their relentless advance." Be candid with your customers, he urged, adding in a stern voice, "We cannot escape these cost increases any more than farmers can. At the same time, we must not use increased costs as a disguise or pretext to gouge them."

What is likely to happen to nitrogen and phosphate prices over the next four years was explored by L. L. Jaquier, head of W. R. Grace & Co.'s Ag-

L. L. Jaquier of W. R. Grace & Co. had his audience buzzing as he made these projections on prices for nitrogen and phosphates in '85.

OUTLOOK FOR 1985

• HIGHER PHOSPHATE COSTS

Diammonium Phosphate (DAP)
Production - Central Florida

	1980	1985 (Proj)	Inc/(Dec) $/Unit	Inc/(Dec) %
Price of Sulfur ($/L Ton, FOB Tampa, Fla)	$118	$188(??)	$70	59%
Fixed Capital Cost New Plant - ($/Ann Ton DAP) (a)	$244	$386	$142	58%
Cost of DAP ($/S Ton)				
Sulfur	$50	$80	$30	60%
Phosphate Rock (b)	23-33	40-47	17-14	74-42
Ammonia (b)	13-39	70-123	57-84	438-215
Processing	47-58	63-80	16-22	34-38
Total	$133-$180	$253-$330	$120-$150	90%-83%

(a) Facilities for sulfuric acid, phosphoric acid and DAP production. Phosphate rock, ammonia and sulfur excluded.

(b) Phosphate rock and ammonia charged at cost; no provision for return on investment.

• ARE THESE COST INCREASES AFFORDABLE?

	1980 (Est Avg)	1985 (Proj.)	Inc/(Dec) 1980-1985
Cost of Natural Gas - ($/Mcf)	$2.10	$6.00-$12.00	$3.90-$9.90/Mcf
Cost of Ammonia ($/S Ton)			
- At Plant	$109	$270-$500	$161-$391/Ton
- To Farmers (Spring)	232	425-665	193-433/Ton
Cost of DAP ($/S Ton)			
- At Plant	$156	$253-$330	$97-$174/Ton
- To Farmers (Spring)	298	470-545	172-247/Ton

• ARE THESE COST INCREASES AFFORDABLE?

		Cost of N and P_2O_5 Fertilizers			Potential Cost Increase 1980-1985 Due to N and P_2O_5 Fertilizers	
			1985			
	1980	1980	Low	High	Low	High
Farm Price of Corn ($/Bu) (a)	$3.43	40¢	65¢	89¢	25¢	49¢
Retail Price of Choice Beef ($/Lb)	$2.38	4¢	7¢	10¢	3¢	6¢
Retail Price of Pork ($/Lb)	$1.40	3¢	5¢	7¢	2¢	4¢

(a) Estimated average price U. S. farmers will receive for 1980 corn crop.

ricultural Chemicals Group.

Jaquier projects increase in nitrogen consumption for the current fertilizer year from 2 to 7%, with phosphate increases from 4 to 8%, based on higher crop prices and more acres planted to corn and wheat, with cotton and soybean acreage at 1980 levels or slightly below.

It was the projections for 1985 that had everyone buzzing. Jaquier looks for cost of producing a ton of phosphate rock in Central Florida to increase 77 to 95% over the next four years, while cost of a ton of diammonium phosphate delivered to the farm gate will jump from an estimated average price of $298 in 1980 to $470–$545. Cost of a ton of ammonia, he projects will go from an estimated average price of $232 last spring to $435–$665—an increase of $193 to $433/ton! (See accompanying tables on page 66.)

"Prices are going to be a real shock," Jaquier noted in an understatement. "Will we be priced out of the market? I don't think so."

To back up his evaluation, the W. R. Grace executive cited the following figures: "In 1980, corn was selling at an average price of $3.43/bushel. It cost 40 cents per bushel for the nitrogen and phosphate used. In 1985, the same amount of nitrogen and phosphate would cost 65 to 89 cents/bushel. To offset the higher priced fertilizers, the retail price of beef would have to go up 3 to 6 cents, the retail price of pork, just 2 to 4 cents.

"In 1980, 16.2% of U.S. disposable personal income was spent on food," he noted. "The potential increases due to increased prices of nitrogen and phosphate fertilizer would be 0.1 to 0.3% of the disposable personal income."

Analyzing the Rail Situation

At a special seminar for retailers held during the TFI meeting, Thomas J. Regan, vice-president of corporate traffic and distribution for International Minerals & Chemical Corp., discussed the rail deregulation act and its ramifications.

Looking at quantity and quality aspects, Regan noted that quantity of rail service will probably be less, but quality is going to improve. "I personally feel that this will improve. Some of the factors indicating this are: (1) The railroads in the past three years have increased their rail fleet significantly, especially covered hoppers; (2) in addition to increasing their rail car fleet, they have increased the power units in their systems; and (3) they are definitely concentrating on high density line movements.

"In addition, there is a brand new aspect available to both the shipper and the railroad for developing satisfactory service. The new law permits the railroad and a shipper to enter into a contract—one in which not only the rate but the service requirements can be detailed. Let's face it, in order to get the attention of the railroad with regard to a contract arrangement, you must have a competitive or alternative system which could be used to take the tonnage off the rails. After all, why should they listen to you and bind themselves to a lower rate and more stringent service conditions—or both—if they are not threatened with the loss of revenue through removal of the tonnage," he noted frankly. "Nevertheless, this avenue is available for establishing satisfactory service to those shippers who can make use of it."

Regan told the retailers that the type of service that will be disappearing are the low density lines—lines that carry less than 1 million ton miles of traffic per mile of line per year. "These are lines associated with service to small country elevators, small manufacturing locations, and the like," he noted.

Summing up, Regan told the retailers that:

- Rail rates are going to be higher in

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the future, particularly for the bulk shipper.

- There will be increasing use of contracts of affreightment with the railroads, and, as a result, the amount of information available concerning freight rates will be "drastically reduced."
- There will be a drastic reduction in the light density rail lines.

"If you suspect your operation is a possible candidate for abandonment—start planning your course of action now," Regan advised.

A Strong Call for More Research

Senator Thad Cochran (R-MS), who is chairman of the subcommittee on production, marketing, and price stabilization of the Senate Agriculture Committee and head of the agricultural appropriations subcommittee of the Appropriations Committee, gave TFI members some insight on what to expect from the Senate, where Republicans are in the majority for the first time in over 25 years.

Cochran looks for an extremely busy session "since the 1977 Farm Act expires this fall and we must renew or rewrite an omnibus farm bill." He told TFI members that he has already met with Agriculture Secretary John Block and is interested in working to promote and expand American farm exports.

He also voiced support for "continuing sound agricultural research and development programs that have helped make American agriculture the most productive in the world. We're on the brink of a decade of unparalleled growth but we could lose the opportunity if we're not careful."

Cutting back on agricultural research would have an adverse impact on our ability to produce, he warned, adding that there are "better ways of dealing with insects, diseases, we can sharpen our fertilizer recommendations, improve our methodology." He urged the private sector to develop a partnership with the universities and the government to further research.

Giusti Elected Chairman

New chairman of the board of TFI is Dr. Gino P. Guisti, president of Texasgulf. Vice-chairman is Judson H. Drewry, president of the fertilizer group and senior vice-president of International Minerals & Chemical Corp. Ed Wheeler was re-elected Institute president.

Others elected to the executive committee were: D. William Calvert, Agrico Chemical Co.; Richard H. Matzke, Chevron Chemical Co.; Dan C. Hutson, Hutson Co., Inc.; David E. Steger, Agrichem Inc.; and Frank C. Miller, Willmar Manufacturing. Tom C. Parry, of Mississippi Chemical Corp., immediate past board chairman, serves as *ex officio* member. **FC**

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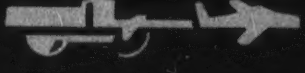

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Conduct Your Own Fly-In

A visual pattern assessment test may not be the most accurate test available but it will allow you to check your pattern frequently and to make the correct adjustments.

By DENNIS K. KUHLMAN

SIGNIFICANT strides have been made during the past few years in the improvement of aerial application equipment, formulations and techniques for the safe use of pesticides. This has resulted in reduced damage claims from losses of materials outside designated target areas, as well as providing greater safety for mixers, loaders, and pilots involved in pesticide use. However, little has been done to improve the pilots understanding of his aircraft and dispersal systems. It is the pilot's responsibility to properly set-up his aircraft for his individual requirements.

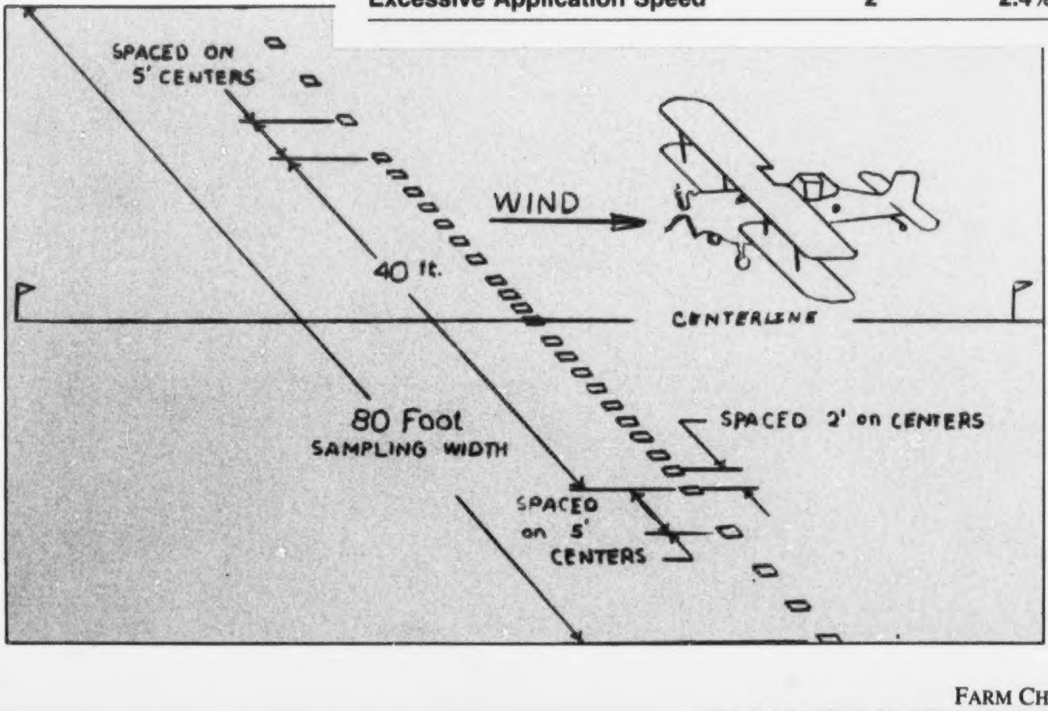
During 1980, eighty-four aircraft in six states were "patterned" to determine their spray distributions. Table 1 indicates the areas and frequency of problems found with these aircraft during the fly-in clinics. It should be noted that many aircraft had multiple problems.

Fly-in techniques vary greatly from location to location. However, until recently, at best they were crude ap-

Mr. Kuhlman is assistant professor in the Department of Agricultural Engineering, Kansas State University. This article was excerpted from a talk on Fly-In Technology for Agricultural Aircraft presented at the National Agricultural Aviation Association annual meeting in December.

Table 1. 1980 Aircraft Pattern Results (84 Total Aircraft)

Problem	Number	Percent
No improvement made	4	4.8%
Spray System Leaks (Total)	25	29.8%
Diaphrams	14	16.7%
Pump Seals	5	5.9%
Connectors	9	10.7%
Extremely Worn Nozzle Tips	60	71.4%
Propwash	26	30.9%
Overcompensation for Propwash	25	29.8%
Plugged Nozzles	23	27.4%
Wingtip Vortex	62	73.8%
Excessive Application Speed	2	2.4%



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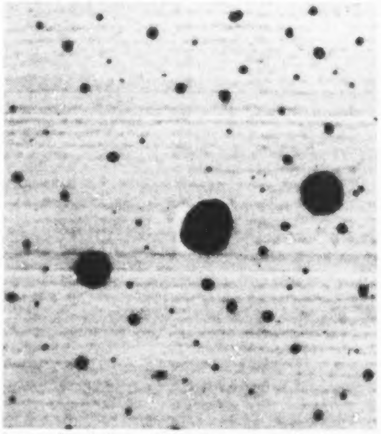
proximations with little scientific background. The visual pattern assessment and similar methods were and are the best available for an individual applicator who does not have the opportunity to use more scientific procedures.

The visual pattern method is quick and requires no complicated equipment. This visual analysis allows the pilot to check his pattern frequently and to adjust his equipment quickly for a particular application. Approximately 30 minutes is required.

Swath pattern testing should duplicate the field situation in terms of aircraft spray height, airspeed, power settings, spray pressure, and nozzle locations. The best time for testing is early in the morning before the sun heats the ground and causes thermal turbulence. The plane should always be flown directly into the wind and testing should be limited to days when the wind speed is less than 10 MPH.

The general test layout is shown in Figure 1. The sample line can be individual sheets of paper or adding machine paper spread out in a continuous line. The length of the sample line should be a minimum of 80 feet. Before testing the aircraft make sure that all nozzles, screens, boom, etc., are clean and rinsed. Put about 30 gallons of water into the spray hopper and add enough water soluble dye to make a dark solution. Fly a short pass (or spray on ground to purge booms) and check for leaks around individual nozzles and pump area. The dye will make any leaks or plugged drop pipes easy to spot. Determine the wind direction and align flags as indicated in Figure 1 about 100 yards on each side of the sample line.

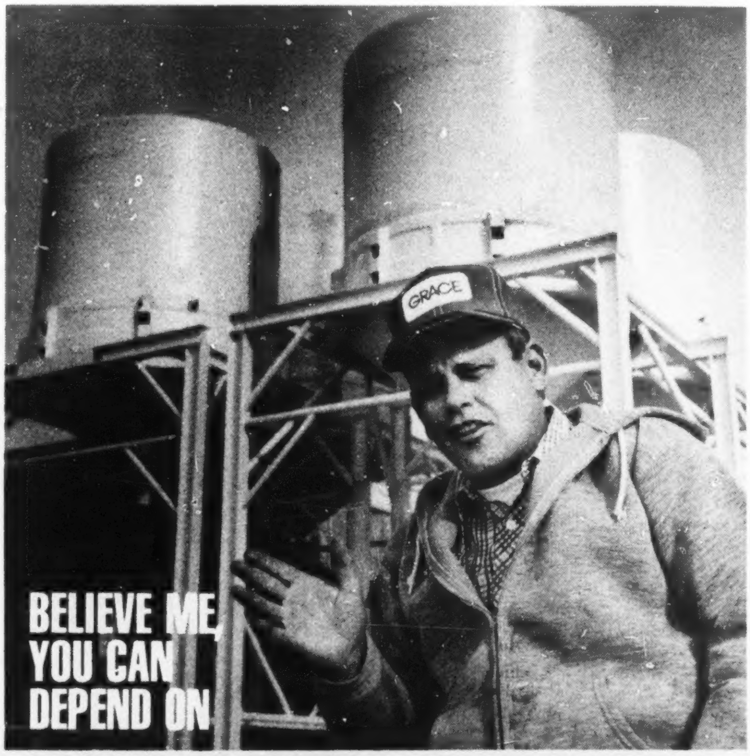


Large droplets resulting from pump leak.

After aircraft takeoff, purge the spray lines making sure that dye leaves the end nozzles. Align the aircraft with the flags on a spray run that duplicates actual field practices. Have the spray on at least 100 yards on both sides of the sample line while maintaining straight and level flight to assure a representative pattern. It is a good idea to remove the paper and repeat this test to make sure that the run was representative of typical spray deposition.

Visual evaluation requires some experience but common problems with spray uniformity and swath width can be determined. Scan the entire sample line looking primarily for uniformity of deposition. Dark dye is much easier to evaluate than a diluted dye. Things to watch for include light drop density areas around the centerline and uneven densities toward the wingtips. The effective swath width will be considerably narrower than the distance between the outside samples where dye is evident.

Gradual dye level reduction at the pattern edges is ideal as this allows for swath overlap. But the only way to get the proper overlap is to locate the point where the dye density is about one-half of that found toward the center of the pattern. The distance between these one-half density points on each wing will be the effective swath width. **FC**



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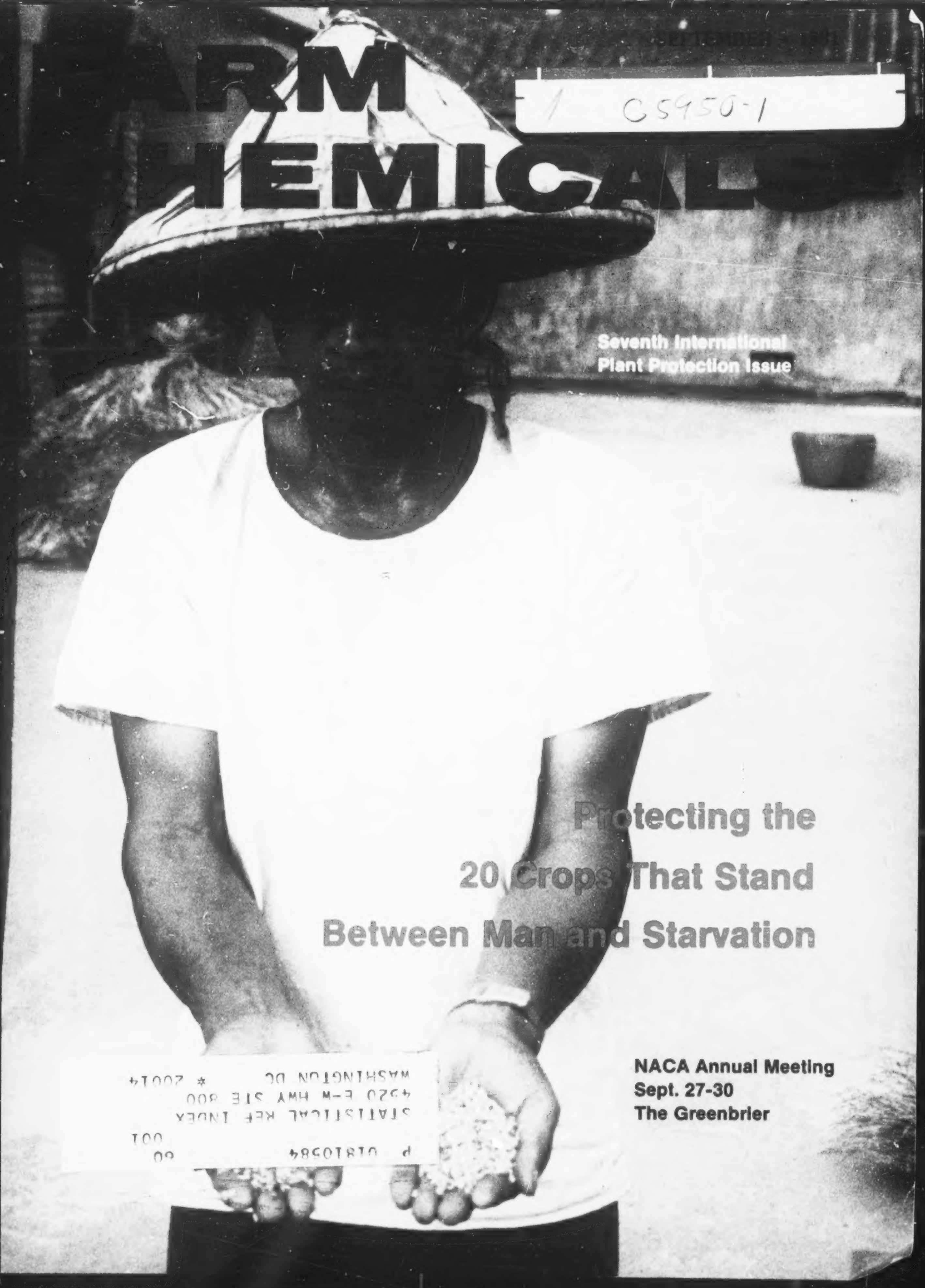

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Plant Protection Issue

Protecting the 20 Crops That Stand Between Man and Starvation

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The Cover Story

The crop protection chemicals industry plays a vital role in helping to protect rice and the 19 other crops that stand between man and starvation. But research must continue to find new methods of control and to improve the productivity of agriculture worldwide. In this special issue, FC focuses on changes being proposed in U.S. pesticide registration and patent laws that could have tremendous impact on future development. *Cover photo by Dr. Sylvan H. Wittwer*

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THE 20 CROPS THAT STAND BETWEEN MAN AND STARVATION

Wheat
Rice
Corn
Potatoes
Barley
Sweet Potatoes
Cassava
Soybeans
Oats
Sorghum
Millet
Sugar Cane
Sugar Beets
Rye
Peanuts
Field Beans
Chick Peas
Pigeon Peas
Bananas
Coconuts

Looking for target crops in your research programs? These crops are the major markets of today—and of the future.

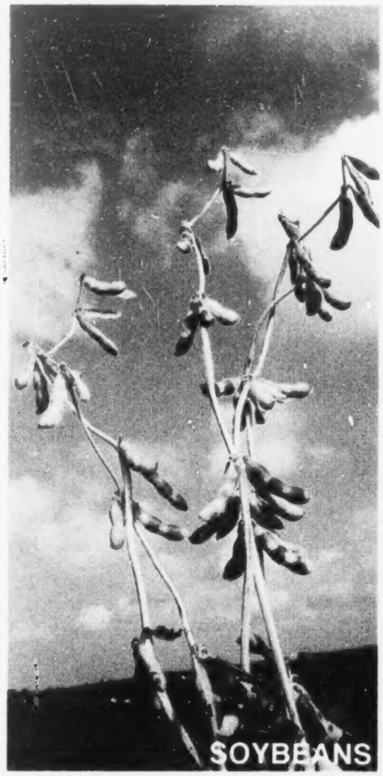
By SYLVAN H. WITTWER

PLANTS provide directly or indirectly up to 95% of the world's food supply. Thus, any reserve technologies which may be called up to insure future food supplies must reside in improved crop production. Of the 350,000 species of plants on earth only about 0.1%, or less than 300, are currently used worldwide for food.

Globally, 20 plants essentially stand between the world's people and starvation. They are wheat, rice, corn, potatoes, barley, sweet potatoes, cassava, soybeans, oats, sorghum, millet, sugarcane, sugar beets, rye, peanuts, field beans, chick peas, pigeon peas, bananas, and coconuts. The cereal grains alone (wheat, rice, corn, barley, oats, rye, sorghum, millet) provide over 60% of the calories and 50% of the protein consumed on the earth.

Any new technologies for increasing production should not ignore these

One of agriculture's strongest and most articulate spokesmen, Dr. Wittwer is director of the Michigan Agricultural Experiment Station and assistant dean of Michigan State University's College of Agriculture. He is a frequent member of food production fact-finding missions sponsored by the Overseas Development Corp., and has participated in the World Task Force on Food sponsored by the Kettering Foundation and the USSR to improve cooperation in solving global problems.


SOYBEANS

SORGHUM

CORN

OATS

PEANUTS

crops. The international agricultural research centers have assembled large numbers of accessions (varieties and cultivars) of the major food crops. This includes 40,000 for rice, 26,000 for wheat, 13,000 for corn, 15,000 for sorghum, and 5500 for pearl millet. Included also are 12,000 for potatoes, 2000 for cassava, 11,300 for chick peas, 6000 for pigeon peas, and 21,000 for field beans with 7000 for peanuts (2).

Annual losses from pests as shown in Table 1 are enormous (4). A reduction in these losses could result in significant increases in food for people without bringing any new land into production. Pests continue to cause farm production losses in the U.S. equal to 30% of the sales value.

All major crops suffer losses before harvest that exceed 20%. The range, persistence, and severity of pests in the tropics and subtropics are more extreme than they are in temperate zones and less is known about them (Table II). It is still not possible to grow wheat in the lowland tropics primarily because of pest problems.

Increased use of integrated pest management practices should reduce the amounts of pesticides applied per acre of cropland, but total pesticide use will increase. It is projected that the total use of all chemicals in agriculture will rise during the next 20–50 years. Otherwise, it will not be possible to meet the increasing demands of rising populations and the desire for improved diets. The impact of increased use of chemicals in agriculture will have a growing effect in the environment. This will be especially so if aerial applications of pesticides increase (7).

Have Altered Course of History

Pests have been a major factor in causing instability and risk in crop production and even have altered the

TABLE I. ***Losses From Pests and Potential Benefits From Control*** **(4)**

Crops	Percent of Loss	20% of Current Loss Presented (million tons)	Millions Fed Each Year Calories and/or Protein
Rice	46	56	177
Wheat	24	23	82
Corn	35	31	121
Millet/Sorghum	38	11	44
Potatoes	32	30	25
Cassava	34	11	16
Sweet Potato	26	9	12
Soybeans	29	5	86
Peanuts	40	2	21
Bananas	31	—	—

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TABLE II. ***Number of Crop Diseases in Temperate and Tropical Regions***

Crop	Temperate	Tropics
Rice	54	500–600
Corn	85	125
Beans	52	250–280

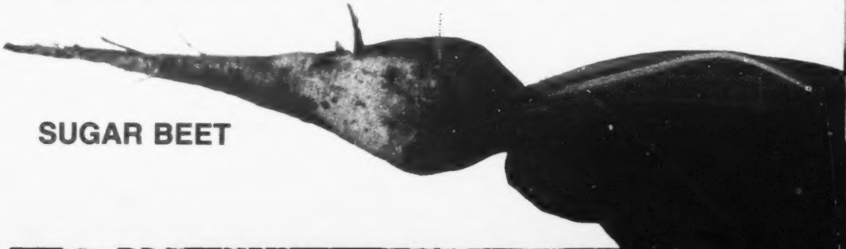
course of history. In each instance one of the 20 crops that protect the world from starvation was afflicted.

The great potato famine from late blight *Phytophora infestans* in Ireland in the mid-1800s resulted in a loss of 2.5 million people by starvation and migration. There were wheatless days in 1917 in the U.S. from stem rust epidemics on wheat. The great Bengal famine of 1943 was associated with *Helminthosporium* brown spot on rice. All Victoria-derived oats were afflicted in the mid-1940s by a fungus causing the Victoria blight. A warm moist summer in 1970 brought on the southern corn leaf blight and the loss of one-seventh of America's number one crop for that year. From 1974 to 1976 there was a shift in brown planthopper biotypes that afflicted large acres in the Philippines and Indonesia planted to a few semi-dwarf strains of rice, and in India in 1973 there was a downey mildew epidemic in pearl millet (5).

Chemicals will play an increasingly important role in protecting the world's 20 critical crops from pests.

Corn. The United States produces over 50% of the world's supply (3). Corn production in the U.S. represents a unique package of plant protection technology. There is almost universal use of fungicidal and insecticidal seed protectants for control of seed corn maggots and other insects and seed decay. These seed treatments result in stability of production. They enable early precision planting without reduction of stands for high yielding early hybrids (1).

Pesticides are used for the control of cutworms, stem borers, earworms, and rootworms. Insecticides are banded on the soil over the row at planting time or aerially applied to kill adult beetles. Leaf blights, stem

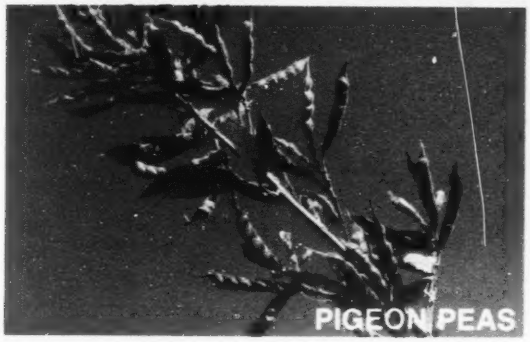

SUGAR BEET

SUGAR CANE

COCONUTS

BARLEY

SWEET POTATOES



PIGEON PEAS

RICE

CASSAVA

rots, streak virus, and stunt may seriously impair yields if not controlled. Downey mildew is the most serious disease in the tropics. Seventy-nine percent of the corn planted in the U.S. is treated with herbicides making up 45% of the total herbicide usage in the nation (Table III).

Potatoes. Potatoes are the world's fourth most important food crop. There was a remarkable jump forward in production from 1940 to 1950 whereby yields more than doubled in one decade. New chemicals originating from World War II technology became available and for the first time it became possible to control flea beetles and leafhoppers. Meanwhile, great progress has been made in the chemical control of late blight, early blight, seed piece decay, and nematodes.

Much of the progress in potato production since 1940 has occurred as a result of more timely and effective use of pesticides. Fifty-seven percent of the acres used for potato production in the U.S. are treated with herbicides, and insecticides and fungicides are used on 77% and 49% of the crop, respectively (Table III).

Rice. More people in the tropics and subtropics look to rice as their mainstay than any other crop. China is the No. 1 producer of rice with 35% of the total crop, and India is No. 2 with 22% (3).

Paddy rice is the world's most extensively irrigated crop. It may be grown on the same area year after year. Weeds are controlled by purposeful flooding. Without fertilizers and pesticides, yields were approximately 1.5 metric tons per hectare. Yields much greater than this are now achieved with new genetically improved varieties and with fertilizers and pesticides.

The use of pesticide chemicals pays off as new varieties and fertilizers are introduced. The ultimate will be insect and disease resistant varieties. Devastating insects include the brown planthopper, stem borers, leaf hoppers, Gall midge, and whorl maggot. Blast is the most important fungus disease. It is now partially under control for lowland rice in Asia, but is still a major threat for upland rice in Africa. Other diseases are bacterial blight, tungro, and grassy stunt.

The use of selective herbicides is essential for direct seeded rice in the U.S., France, Italy, Colombia, Venezuela, and Brazil. Ninety-two percent of all U.S. rice is treated with herbicides (Table III).

Wheat. The USSR is the world's leading producer of wheat with 27% of the total, followed by the U.S. with 11% and China with 10%. There is no effective means of controlling weeds other than through the use of selective herbicides. Globally, about 200 million acres of wheat are sprayed annually with selective herbicides with yield increases resulting therefrom of 10 to 20%. Thirty-eight percent of the wheat acreage in the U.S. is herbicide treated. There are, in addition, many insects and fungus diseases that afflict wheat.

Multilines have now been developed for rust resistance, and these resistant varieties coupled with cultural practices and biological controls show great promise for the future. It is now becoming possible to select effectively for resistance to insect and diseases in the cereal grains.

Other Crops. Serious pest problems exist with others of the 20 crops that protect the world from starvation. **Grain sorghum** seeds are usually treated with a protectant to prevent decay. Greenbugs, shoot flies, stem borers, and midge have to be controlled. **Barley** is afflicted with rust, powdery mildew, virus stripe, and leaf spot.

Soybeans, while relatively free of diseases and insects in the northern corn belt of the U.S., are subject to many disease and insect problems in the South and in the Mississippi Delta. Eighty-eight percent of the U.S. soybean acreage is treated with herbicides and 8% with insecticides.

Peanuts in the U.S. are troubled with rusts, leaf spots, mottle, rosette, stunt, and spotted wilt. Seventy-six percent of the crop is treated with fungicides, 55% with insecticides, and 93% of the acreage with herbicides (Table III).

Large quantities of fungicides are used on bananas and there are also bacterial wilts. Nematodes are serious in coconuts. The Porroca disease killed hundreds of thousands of the palms in South America. Little is known of pests that attack coconuts and even less about their control.

Wilts and blights afflict chick peas and pigeon peas. There are about 200 insect pests on pigeon peas, the most serious being borers and pod flies. Field beans are infested with mosaic virus, rust, anthracnose, angular leaf virus, bacterial blights, and aphids with problems much greater in the tropics than in temperate zones (Table II).

Cassava has problems of mosaic, bacterial blights, anthracnose, phoma leaf spot, root rots, mealy bugs, white fly, green and red spider mites, and thrips. Sweet potatoes are afflicted with virus, weevils, aphids, and white flies. Sugar beet production has been discontinued in many former producing areas of the western U.S. because of nematodes and *Rhizoctonia* (black rot) root rots which pose a continuing problem.

TABLE III. ***Pesticide Usage in the U.S. (Percent Treated—1976)****

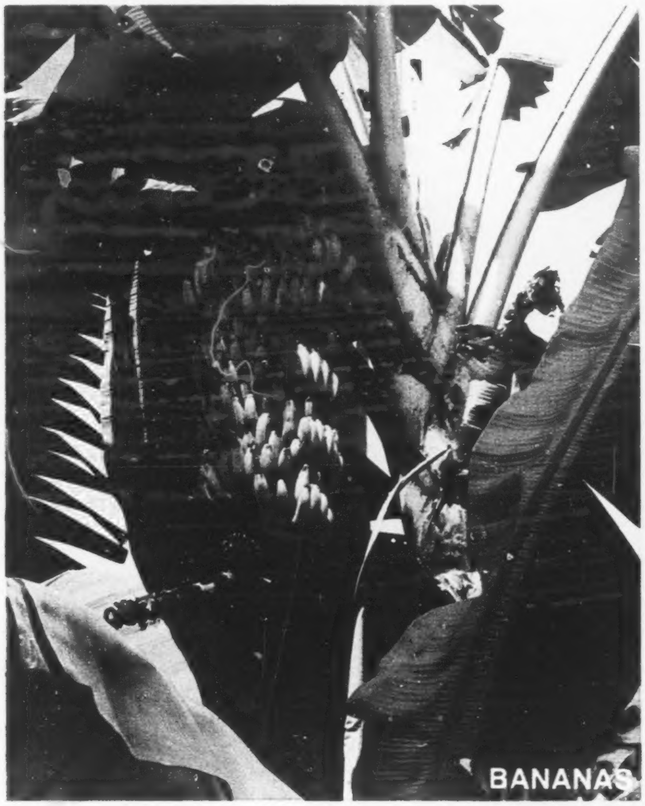
Crop	Herbicide	Insecticide	Fungicide
Corn	79	38	1
Wheat	38	14	1
Soybeans	88	8	3
Rice	92	11	0
Potatoes	57	77	49
Dry Beans	90	—	—
Peanuts	93	55	76

*Data derived from: Eichers, T.R., P.A. Andrilenas, and T.W. Anderson, 1978. Farmer's Use of Pesticides in 1978. USDA Agricultural Economic Report No. 418; and Pimental, D. *et al*, 1978. Benefits and Costs of Pesticide Use in U.S. Food Production. Bioscience 28:772, 778–784.

Battle Not Over

The battle has not been won and will go on in protecting the 20 crops, and a few others, that feed the world. There are now available many lines of attack: Development of resistant varieties; cultural practices; biological controls; and chemicals. Chemical usage will increase but will be better targeted and timed. Otherwise, maximum production from our limited land and water resources would not be possible. Increased productivity of food is absolutely essential if we are to meet the needs of rising world populations, establish strategic food reserves, and satisfy the desire of all nations for more improved and abundant diets. **FC**

Photos by Sylvan H. Wittwer



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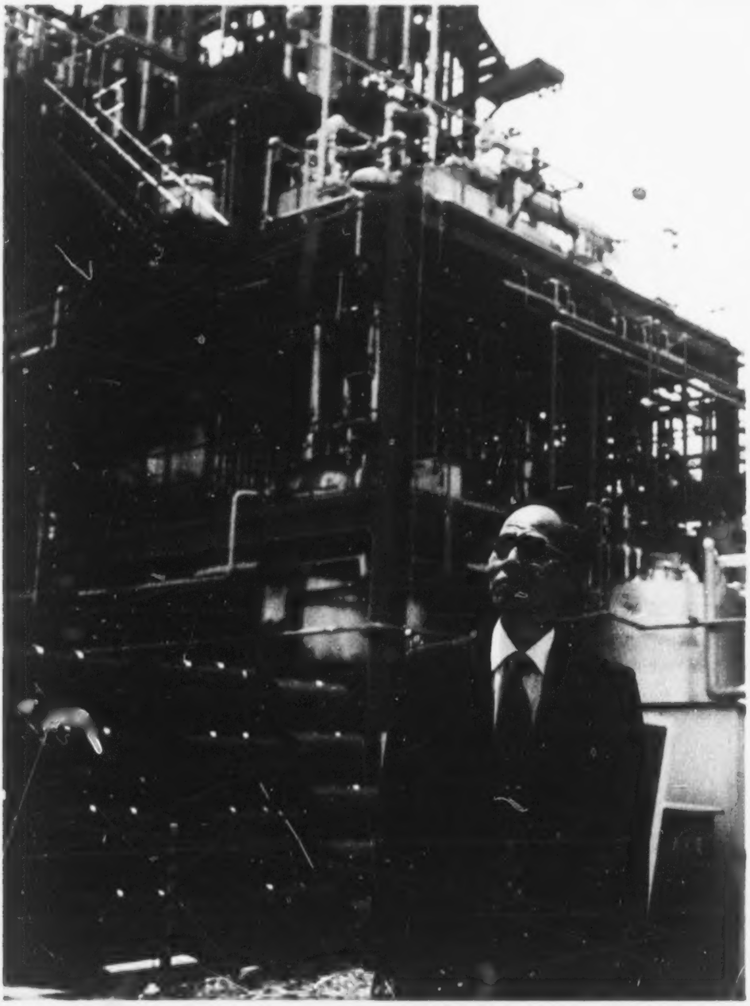


Shiro Mochizuki, president, Kumiai Chemical Industry Co., Ltd.

JAPAN

"We're making up for lost time with herbicides"

FC Special Report

Japanese pesticide producers are driven by lure of new markets

Having been successful in developing insecticides and fungicides for other markets these innovative companies are now concentrating on herbicides for U.S. corn, cotton, soybean, wheat, and rice markets.

"WE are driven!" That's the catchy Datsun commercial that has caught the attention of automobile lovers for several years. But what about Japan's pesticide producers—are they driven by the same forces that propelled Datsun, Toyota, Nissan, Mitsubishi, and other Japanese auto makers to the top?

The answer that FC editors received to that question on a recent trip to Japan is that what drives their agricultural chemical divisions is the same deep respect for technology that all their industries share—with the added incentive of getting into the U.S. cotton, corn, soybean, wheat, and rice markets with new herbicides.

As one spokesman for the industry put it, "We've been slow recognizing the need for herbicides because it was just natural that we would solve our insect and disease problems first. But now the emphasis is on herbicides."

And that's what appears to be taking place as Kumiai, Nippon Soda, Nissan, and Ishihara Sangyo Kaisha all have exciting herbicide entries close to registration or under test in the U.S. Sumitomo claims to be close to developing one, too.

This is the way to the top, all right, but it will "be awhile" before you see a Japanese pesticide company in the "top 10 world pesticide marketers," in spite of their amazing achievements—such as Sumitomo's development of what some experts say is the best pyrethroid in the market. What's preventing Japanese companies from entering these major world markets in the same way as Bayer, Ciba-Geigy, and other huge companies have done?

To answer that question, you must understand how Japan looks at the market.

One "Japan-watcher" told FC, "They have a different approach to marketing. Sometimes they seem to be extremely conservative, but the truth is they are very patient people. They're willing to wait . . ."

Hideo Mori, general manager of Sumitomo's Agricultural Chemical Division, doesn't get excited about the "rating game" anyway. "It is difficult to 'rate' a company in the world market if its sales are based on technical material such as ours are. Project those figures to the value of formulated products and they're more than double," he said.

Historically, Japan has been hesitant about establishing agrichemical subsidiaries overseas because of the success of their trading companies, sogo shosha, in introducing their products over the world. As Mori said, "Sumitomo Soji operates in 136 countries compared to Sumitomo Chemical's 80 countries."

The profit margins over the years have been termed "extraordinary" for Japanese pesticide divisions in some markets. However, increasing costs of developing new compounds and stricter government regulations will bring about some changes in marketing of pesticides in the future. Sumitomo, for example, is attempting to gain experience in pesticide formulation through a new partnership with a company called Yamamoto Nohyaku Co.

Another fact about the Japanese pesticide industry is that it isn't entirely made up of large companies. An organization that is not a household word outside Japan but which just might beat them all in the race to enter the "charmed circle" of world pesticide leaders is Kumiai Chemical Industry Co., Ltd.

The leader in domestic pesticide sales, Kumiai has caught the attention of the pesticide world because of its impressive research capability. The company merged its research and development with Ihara Chemical Industry Co., Ltd. The latter has always had a close working relationship with Kumiai and is known for its manufac-

turing prowess as well as its successful synthesis effort over the years.

"It's always been hard to tell the two companies apart," one pesticide expert told FC. "They seemed like one and the same."

Kumiai has become a major factor in the international market with Saturn herbicide—called Bolero in the U.S. Kumiai and its licensee, Chevron, are eagerly awaiting an EPA registration for use of Bolero on rice.

Although the Japanese pesticide industry is dominated by giant corporations which are involved in everything from automobiles to pesticides, S. Mochizuki, president of Kumiai, is not convinced that this necessarily gives them an edge in world pesticide marketing.

"Development of pesticides is a far more complex field than, say, auto production," he said. "It isn't easy satisfying the Ministry of Agriculture, Forestry and Fisheries."

With the increasing use of pesticides in Japan the past two decades came concern about environmental pollution, residual toxicity, and accidental poisonings. Starting in 1955 parathion was gradually replaced by new organophosphorus insecticides, and its use was prohibited in 1971. Organomercuric fungicides were banned in 1968 and replaced by nonmercuric chemicals and antibiotics.

It is expected that the production and marketing of aldrin, dieldrin, and endrin insecticides for purposes other than research will be banned this fall. Companies in Japan ceased manufacturing these products in the early 1970s when their use in agriculture was banned. Japanese insecticide formulators for industrial and home markets have been importing these products, but this will cease with the anticipated ban.

It is expected that DDT will meet the same fate. Its use in agriculture was banned 10 years ago.

In the 1980 pesticide year ending September 30, production and deliveries of pesticides totalled about $1.5 billion (based on ¥220 per U.S. $1). Imports totalled about $240 million and exports about $259 million.

Why have Japanese pesticide companies been so successful recently in the development of new pesticides, especially herbicides? Talk to any U.S. pesticide executive who has visited a Japanese company and he'll tell you that it's because of the national obsession with science! There's even a new city in Ibaroki Prefecture devoted entirely to science. It's called Tsukuba Science and Education City. Almost unknown outside Japan, it's a new municipal complex of research laboratories and educational facilities. Tsukuba grew out of radical thinking about future directions of Japan and the need for revolutionary ideas.

The Ministry of Agriculture, Forestry and Fisheries, which has almost 30 research institutes—among them the prestigious National Institute of Agricultural Sciences—was recently moved to Tsukuba Science and Education City.

It has often been said that what is making the Japanese move so fast technologically is their emphasis on consensus, an assumed cooperative relationship between the various branches of government rather than the adversary approach which has permeated the U.S. system.

This spirit carries over into agricultural chemicals R & D.

"Japanese pesticide companies literally 'swarm' over specific problems with teams of technical specialists," FC was told. "It's unbelievable how many well trained people they can bring to bear on a problem that is holding up progress."

Sumitomo is a good example of this. As a result, it has been the leader in international development of pesticides among the nation's pesticide producers. In fact, it is the only company whose international sales exceed domestic sales.

"Hopefully, we'll remain No. 1," Mori said. "We've doubled our pesticide sales since 1975. However, this has been technical, not formulated, products."

Sumitomo scientists spent more than 30 years developing their pyrethroid insecticide. Sumicidin is their top product and they feel that it will continue to be the "No. 1 pyrethroid" for many years. In the U.S. where the product is known as Pydrin, Shell Chemical is building its own new "multi-million pound" Mobile, AL plant.

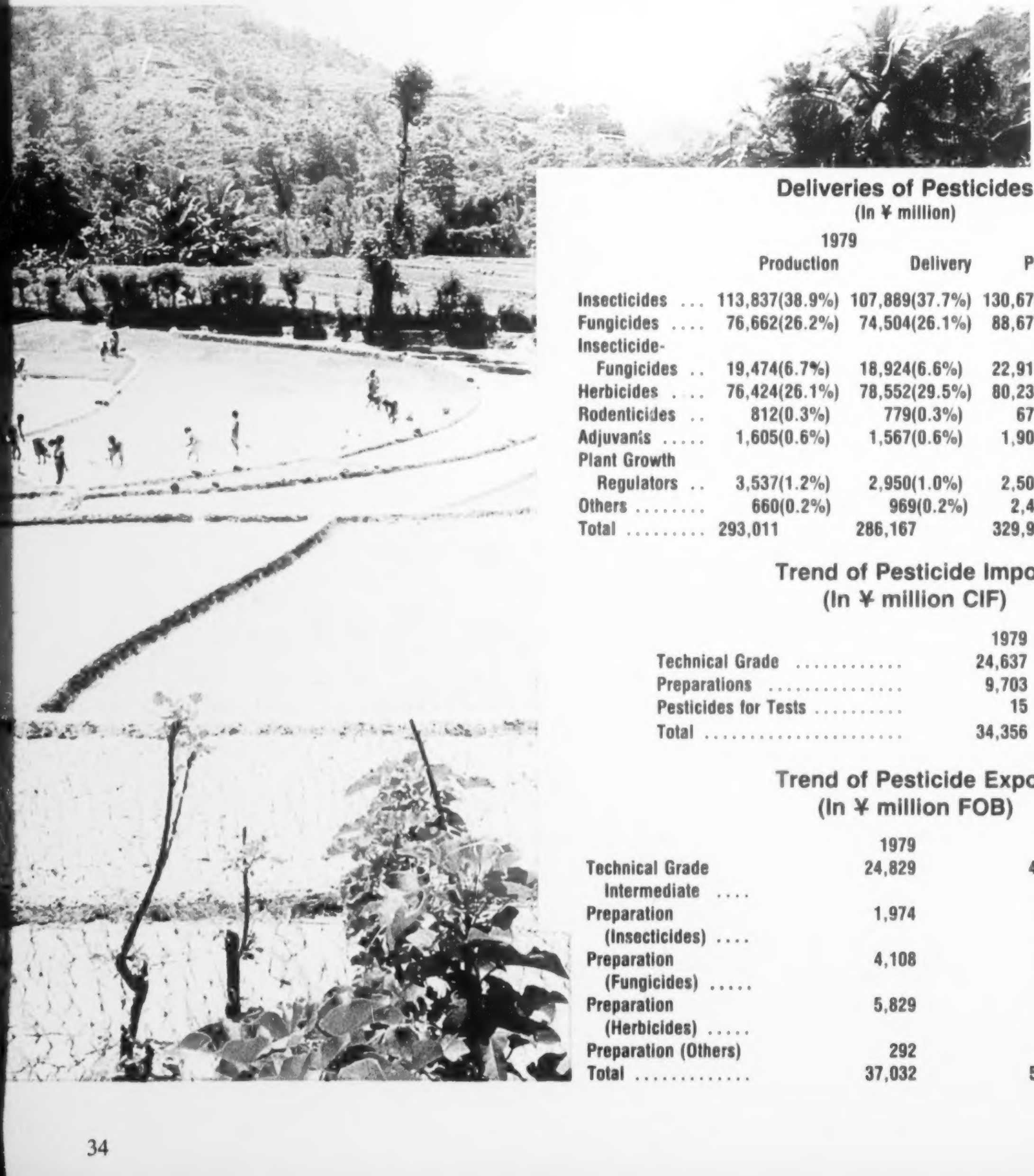
The Japanese pesticide industry is one of marked contrasts. Nissan Chemical Industries, Ltd. has not had a proprietary it could call its own, but it's taken dead aim on the U.S. cotton and soybeans markets with a new herbicide that has grabbed the attention of weed control experts. Referred to as NCI-96683, the compound is receiving preliminary evaluation as a selective, postemergence herbicide. In addition to possible introduction in the U.S. soybean and cotton markets, the company is hopeful that it will become a "leading contender" in the European sugar beet market.

Nissan racked up big sales with such products as Elsan, EPN, Swep, 2,4-D, and MCP and ranks as one of the leading exporters in the industry. Elsan is marketed in Southeast Asia, especially Korea and Indonesia, and the Middle East (including Iran and Iraq). The U.S. cotton market is the main target for EPN, and Nissan is also promoting its use in Latin American countries.

Nippon Soda also has been making news this past year as Topsin-M (thiophanate-methyl) has had a major expansion of its label in the U.S. EPA has granted Nippon Soda's licensee, Pennwalt Corp., registrations for use of the product on soybeans. The company's venture with BASF seems destined to pay off, too. This involves Poast (NP55), a new postemergence grass herbicide for which BASF is attempting to obtain an EPA registration in cotton, soybeans, alfalfa, and vegetable crops. This compound belongs to the same group as aloxydimsodium (NP48 Na) which is being marketed under such trade names as Kusagard and Fervin (Schering AG).

Takeda is Nippon's largest pharmaceutical firm and some experts say it is "Japan's agrochemical leader of the future." This is because of a strong research base which includes com-

Photo by Sylvan H. Wittwer



Deliveries of Pesticides

(In ¥ million)

	1979		1980	
	Production	Delivery	Production	Delivery
Insecticides ...	113,837(38.9%)	107,889(37.7%)	130,678(39.6%)	122,886(38.7%)
Fungicides	76,662(26.2%)	74,504(26.1%)	88,677(26.9%)	87,628(27.6%)
Insecticide-Fungicides ..	19,474(6.7%)	18,924(6.6%)	22,910(6.9%)	22,111(7.0%)
Herbicides	76,424(26.1%)	78,552(29.5%)	80,234(24.3%)	77,600(24.5%)
Rodenticides ..	812(0.3%)	779(0.3%)	677(0.2%)	683(0.2%)
Adjuvants	1,605(0.6%)	1,567(0.6%)	1,900(0.5%)	1,891(0.6%)
Plant Growth Regulators ..	3,537(1.2%)	2,950(1.0%)	2,502(0.9%)	2,495(0.8%)
Others	660(0.2%)	969(0.2%)	2,409(0.7%)	2,000(0.6%)
Total	293,011	286,167	329,987	317,294

Trend of Pesticide Import
(In ¥ million CIF)

	1979	1980
Technical Grade	24,637	39,294
Preparations	9,703	13,343
Pesticides for Tests	15	—
Total	34,356	52,637

Trend of Pesticide Export
(In ¥ million FOB)

	1979	1980
Technical Grade Intermediate	24,829	41,970
Preparation (Insecticides)	1,974	4,137
Preparation (Fungicides)	4,108	2,961
Preparation (Herbicides)	5,829	8,114
Preparation (Others)	292	101
Total	37,032	57,283

pounds that perform differently than conventional chemicals. Padan insecticide, based on a naturally-occurring substance, nereistoxin, has been widely used for its broad spectrum control of insects, and Validacin, an antibiotic fungicide, is being used in many parts of the world against sheath blight in rice and black scurf of potatoes.

Recently, Takeda developed a new insecticide, TI-78, for use against Colorado potato beetle in the European market and vegetable and fruit insects in Japan.

There are other pesticide companies which are making excellent progress in developing new herbicide compounds. One is Ishihara Sangyo Kaisha which has a joint effort with ICI in the development of fluazifop-butyl as an herbicide. ICI reports that their product Fusilade is a systemic herbicide that offers excellent control of annual and perennial grasses. These include seedling johnsongrass, barnyardgrass, crabgrass, panicums (Texas and fall), broadleaf signalgrass, foxtails, wild oats, itchgrass, shattercane, wild proso millet, and volunteer corn. Rhizome johnsongrass is also highly susceptible, as are quackgrass and bermudagrass. A research program with independent cooperators is currently being conducted on soybeans and cotton in the U.S.

Mitsui Toatsu has also been increasing its activities in agrichemical research and development. They have a new herbicide for use in rice paddy fields called Uribest. The company has manufactured such pesticides as MCPA, lindane, chloropicrin, and quintozene.

What's happening in the exciting field of genetic engineering in which Japan is reportedly a leader? Sumitomo's T. Yamamoto, deputy general manager and associate to the board, looks at this as a field in which their pesticide researchers "should be able to make a large contribution." At their Institute of Biological Sciences, "gene splicing" is a separate research area. Yamamoto told FC, "We regard this as a field which should not be limited to pharmaceuticals."

FC learned that other companies were also committed to this field of research. Mitsubishi has a 100% owned basic research organization called Mitsubishi-Kasei Institute of Life Sciences which conducts basic research in "life sciences." Started in 1971, the Institute is highly involved in molecular breeding, or so-called genetic manipulation, which studies, among other things, the propagation of nitrogen-fixing bacteria, blue-green algae, and even new plants.

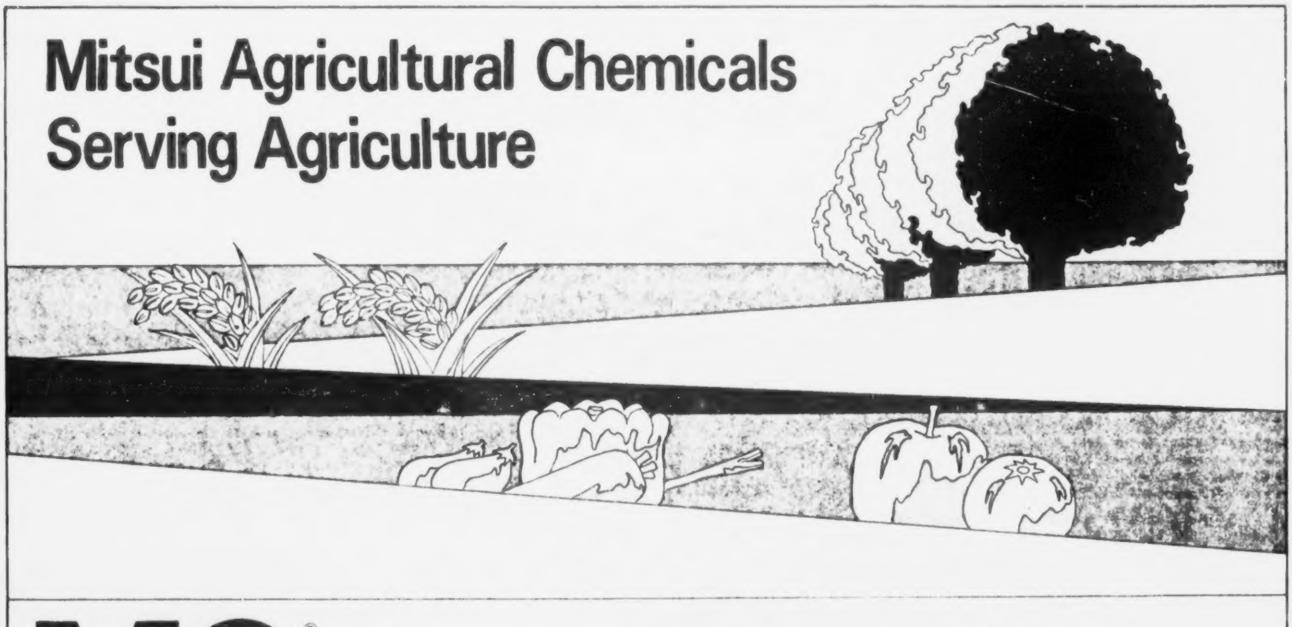
Japan's pesticide achievements are particularly amazing when you consider the restrictions that are placed on its industry. Take land, for example. Sumitomo literally ran out of space at its Osaka headquarters, built its new Takarazuka Research Center on the outskirts of the city, and continues to spread out in outlaying areas. Aerial application of pesticides is being conducted solely by helicopter because of a shortage of landing space and obstacles around the fields. It wasn't until 1958 that the first large-scale application of pesticides by helicopter was carried out on rice fields to control blast disease.

As the acreage of rice fields sprayed from the air expanded, the Agricultural Aviation Association was established in 1962 to set up operations to investigate techniques and apparatus and to provide courses for pilots.

Little wonder that Japan is looking at new approaches to international marketing of its growing pesticide product line, whether it be more partnerships, subsidiary companies, or whatever. One thing is sure, problems will continue to be effectively solved through the spirit of consensus. Nothing detracts these companies from their goal.

Right now their goal is to get into the lucrative U.S. cotton, corn, soybean, rice, and wheat markets. And it appears that they've succeeded in establishing a beachhead. **FC**

Mitsui Agricultural Chemicals
Serving Agriculture



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For Details Circle No. 185 on Postcard

A Look At World Pesticide Markets

Here's an exclusive look at U.S. and world markets for crop protection chemicals by crop, type of pesticide, and area of the world.

HOW did last year's sales stack up, and what are you predicting for next year? What is your 5-year forecast? That's what FC recently asked leading international marketers of crop protection chemicals in a confidential survey.

Their answers reflect continued optimism about the future use of agrochemicals. The respondents pegged 1980 sales worldwide at $11.5 billion (in US 1980 dollars) and look for an increase of $1.1 billion in sales next year. Looking ahead to 1985, they project sales will top $14.3 billion.

The U.S. continues to be the largest single market (and surprisingly, the market most frequently named where the biggest increase in use will occur over the next 5 years), with sales estimated at $3.5 billion at the user's level in 1980. By 1985, they look for U.S. sales to exceed $4.4 billion. Big increases are also projected for Brazil, the People's Republic of China, Mexico, and Japan.

There are factors that could limit pesticide use, however. Cited by the respondents most often were depressed commodity prices, low investment resources in developing countries, government regulations, and trade barriers and other restrictions placed on imports.

Still, two-thirds of the respondents reported that their R&D efforts are expanding, and over half expect to continue to expand their research efforts over the next five years. About one-third of the respondents have broadened their research programs to include genetic engineering and biologicals, as well as naturally occurring insecticides and fungicides.

On the following pages, average figures are presented for 1980 by crop and by U.S., Western Europe, Japan and the Far East, rest of the world, and total world.

The figures represent the best thinking of the leading international marketers. **FC**

Table 1
HOW THE MARKET DIVIDES[1]
(User's Level)
(Millions of U.S. 1980 Dollars)

World (including U.S.)

Pesticide	1980	1982	1985
Herbicides	4,891	5,307	6,022
Insecticides	3,916	4,228	4,764
Fungicides	2,199	2,417	2,772
Other[2]	559	654	758
TOTAL	11,565	12,606	14,316

United States

Pesticide	1980	1982	1985
Herbicides	2,171	2,418	2,760
Insecticides	908	1,013	1,128
Fungicides	226	240	276
Other[2]	199	248	319
TOTAL	3,504	3,919	4,483

[1] Estimated

[2] Includes soil fumigants; defoliants and desiccants; plant growth regulators; pheromones; attractants and viruses; and rodenticides.

Source: FARM CHEMICALS

A Look At World Pesticide Markets

Table 2
THE HERBICIDE MARKET BY CROP— 1980[1]
(User's Level)
(Millions of U.S. 1980 Dollars)

Crop	U.S.	Western Europe	Japan & Far East	Rest of World	Total
Corn	754	99	14	210	1;077
Cotton	142	6	13	160	321
Wheat	97	377	29	119	622
Sorghum	59	8	2	14	83
Rice	53	21	285	70	429
Other Grains	29	204	9	37	279
Soybeans	749	17	22	125	913
Tobacco	17	3	4	8	32
Peanuts & (Groundnuts)	31	—	5	10	46
Sugar Beets	26	200	6	42	274
Sugarcane	14	—	14	72	100
Coffee	—	—	6	18	24
Cocoa	—	—	—	10	10
Tea	—	—	9	14	23
Rubber	—	—	42	10	52
Other Field Crops	29	24	19	20	92
Alfalfa	16	15	1	4	36
Other Hay & Forage	9	4	1	1	15
Pasture & Rangeland	30	12	10	26	78
Fruits, Vegetables & Horticultural Crops	116	169	37	63	385
Fruits and Nuts	(56)	(82)	(17)	(27)	(182)
Potatoes & Vegetables	(60)	(87)	(20)	(36)	(203)
Total	2,171	1,158	528	1,034	4,891

[1] Estimated
Source: FARM CHEMICALS

Table 3
THE INSECTICIDE MARKET BY CROP— 1980[1]
(User's Level)
(Millions of U.S. 1980 Dollars)

Crop	U.S.	Western Europe	Japan & Far East	Rest of World	Total
Corn	242	57	29	90	418
Cotton	212	27	140	539	918
Wheat	13	21	10	32	76
Sorghum	21	6	7	34	68
Rice	11	8	428	116	563
Other Grains	7	14	5	9	35
Soybeans	33	5	13	78	129
Tobacco	24	8	13	38	83
Peanuts (Groundnuts)	18	1	20	29	68
Sugar Beets	8	49	7	28	92
Sugarcane	5	—	10	29	44
Coffee	—	—	4	39	43
Cocoa	—	—	13	26	39
Tea	—	—	31	22	53
Rubber	—	—	13	11	24
Other Field Crops	20	24	22	32	98
Alfalfa	23	10	2	5	40
Other Hay & Forage	4	4	2	9	19
Pasture & Rangeland	5	3	2	8	18
Fruits, Vegetables & Horticultural Crops	262	269	254	303	1,088
Fruits & Nuts	(155)	(192)	(138)	(175)	(660)
Potatoes & Vegetables	(107)	(77)	(116)	(128)	(428)
Total	908	506	1025	1477	3916

[1] Estimated
Source: FARM CHEMICALS

A
Look
At
World
Pesticide
Markets

Table 4
THE FUNGICIDE MARKET BY CROP— 1980[1]
(User's Level)
(Millions of U.S. 1980 Dollars)

Crop	U.S.	Western Europe	Japan & Far East	Rest of World	Total
Corn	6	4	3	8	21
Cotton	12	1	4	10	27
Wheat	7	185	5	75	272
Sorghum	2	3	3	6	14
Rice	5	3	249	51	308
Other Grains	5	76	6	20	107
Soybeans	17	1	5	8	31
Tobacco	3	4	10	12	29
Peanuts (Groundnuts)	34	—	6	8	48
Sugar Beets	5	10	6	13	34
Sugarcane	3	—	4	23	30
Coffee	—	—	6	47	53
Cocoa	—	—	3	11	14
Tea	—	—	12	4	16
Rubber	—	—	11	4	15
Other Field Crops	3	7	3	6	19
Alfalfa	3	3	—	6	12
Other Hay & Forage	1	1	2	3	7
Pasture & Rangeland	1	—	1	1	3
Fruits, Vegetables & Horticultural Crops	119	562	179	279	1,139
Fruits & Nuts	(81)	(443)	(101)	(175)	(800)
Potatoes & Vegetables	(38)	(119)	(78)	(104)	(339)
Total	226	860	521	595	2,199

[1] Estimated
Source: FARM CHEMICALS

THE BIG FIVE SINGLE CROP MARKETS IN 1980[1]
(User's Level)
(Millions of U.S. 1980 Dollars)

No. 1—CORN	
Herbicides	$1,077
Insecticides	418
Fungicides	21
Total	$1,516

No.2—RICE	
Herbicides	$ 429
Insecticides	563
Fungicides	308
Total	$1,300

No. 3—COTTON	
Herbicides	$ 321
Insecticides	918
Fungicides	27
Total	$1,266

No. 4—SOYBEANS	
Herbicides	$ 913
Insecticides	129
Fungicides	31
Total	$1,073

No. 5—WHEAT	
Herbicides	$ 622
Insecticides	76
Fungicides	272
Total	$ 970

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THE COVER STORY

The clipper ship forms an important part of the history of one of the fertilizer industry's pioneering companies. It was a clipper that carried Henry J. Baker from Baltimore to Manhatten where he started H. J. Baker & Bro., Inc., becoming one of the earliest traders of fertilizers and manufacturer of organics such as castor pomace and bird guano. Many of the materials arrived from around the world by clipper ship. Today H. J. Baker is one of the industry's leading trading companies. For the complete story of the company headed by Morse Smith and his brother Rutger, see the article beginning on page 13.

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Chem Systems Predicts Phos Acid Trade Increase

WORLD PHOSPHATE FERTILIZER CONSUMPTION

(Million metric tons P_2O_5)

	1978/79	1984/85	1989/90	Annual Growth (Percent)
North America	6.2	7.1	8.1	2–3
South America	1.8	3.4	5.1	10
Western Europe	5.8	6.6	7.1	2
Eastern Europe	7.9	10.6	13.6	5
Middle East	0.9	1.2	1.7	6
Africa	0.8	1.2	1.6	6
Asia (Free Economy)	2.7	4.3	5.7	7
Asia (Communist)	2.1	3.3	4.6	7–8
Oceania	1.1	1.6	1.9	5
Total	29.3	39.3	49.4	5

PROGNOSTICATORS at Chem Systems Inc. say phosphate fertilizer trade will increase 9% per year during the '80s to exceed 10 million metric tons annually by 1990. Other key findings in their recently published projection of phosphate business include world phosphate fertilizer consumption continuing to grow almost 5% annually with phosphoric acid growth at 6%, higher because of the trend toward use of higher analysis products.

"North America and Africa," the study continues, "will continue as the major phosphate exporters. The free economy countries of Asia will remain the leading importing group but will be challenged by the communist countries including Eastern Europe, USSR, and the Peoples Republic of China. A strong dependency on noncommunist countries by this group for phosphate supplies will result if expected consumption is realized."

Although many technological improvements have occurred, the study doubts that "revolutionary breakthroughs" are likely during the decade. Efficiency and environmental acceptability of phosphoric acid manufacture will continue to improve, but investment in such activities as recovering uranium from phosphoric acid will remain questionable for some time.

Wide price fluctuations are predicted for the short term with phosphate remaining the "most price elastic of the major fertilizer nutrients." However, pressure caused by market and economic forces will act to "underpin strong pricing" for phosphoric acid and phosphate fertilizers due to upward spiraling raw materials prices (especially sulfur) and processing costs for acid manufacture.

The report, *The Future Phosphoric Acid Business* (2 volumes, 772 pages), is available from either of its joint publishers—Chem Systems Inc., 14925 Memorial Dr., Houston, TX 77079; and Chem Systems International Ltd., 28 St. James's Sq., London SW1Y 4JH, England.

Acid Rain Targeted for CAST Study

HORROR stories abound concerning rainfall with the same pH as vinegar falling on fields and cities, and people look with distaste and dread toward their industrialized neighbors upwind. But is acid rain, as the phenomenon has come to be known, a new problem, and is it entirely without redeeming quality?

The Council for Agricultural Science and Technology (CAST) has appointed a task force to look into the subject in depth, and a full report will be forthcoming. CAST emphasizes, however, that this is not the first study group to tackle the subject: "Farmers were contending with soils that had become acid from natural causes associated with precipitation long before the industrial revolution and the dawn of scientific agriculture. Agricultural scientists have studied the nature, causes, effects, and correction of soil acidity for well over half a century, and much has been learned that is now largely overlooked in the educational information being released

To satisfy interests while research is being conducted and assembled, CAST has released what it terms to be "a reasoned perspective based on facts." The source of this "pre-report" information is the American Society of Agronomy, Inc.

The agronomists summarized their findings briefly: "(1) The sulfur and nitrogen in acid rain are plant nutrients; (2) soils and lakes become acid from natural causes as well as from acid rain; (3) the amount of acidity produced in agricultural soils by acid rain is small in relation to the acidity produced there by other causes; and (4) lakes that have become acid and fishless because of acid rain can be neutralized and made suitable for fish, should the presence of fish justify the investment."

Using the society's magazine (*Crops and Soils*, June–July 1981) as a forum, the agronomists pointed out that although sulfur deficiencies have been noted in 32 of the 50 states, none of these is in the Northeast, yet all the southeastern states report deficits. In fact, says the report, "Alabama has a law requiring that all mixed fertilizers sold in the state contain a minimum of 3% sulfur." It is assumed that the northern states receive concentrations of atmospheric sulfur that meet needs.

This sulfur is not unlike the sulfur supplied by fertilizers (nor is the atmospheric nitrogen markedly different from nitrogen in fertilizer, but it is available in smaller than needed amounts). It is, in fact, "utilized by plants as nutrients and of economic value if the amounts supplied are sufficient but not excessive."

G. L. Terman of The Sulphur Institute explains that to achieve moderate to high yields, crops need 8 to 85 pounds of sulfur per acre per year. This amount would fall in 22 to 234 inches of acid rain (pH 4.0) "such as that falling in the Adirondack region of New York." It would be sufficient, that is, if all the rain were sulfuric and if all the acidity were caused by sulfur.

J. C. Noggle, says the report, told the Tennessee Valley Authority in 1979 that acid rain is worth as much as $20 per acre "on the basis of the crops it produces." And Dr. R. G. Hoeft and his colleagues found almost a decade ago that 44% of the sulfur present in alfalfa grown in a Wisconsin test greenhouse in acid-washed sand came from the atmosphere.

Atmospheric acid has been attributed to oxide emissions after 1960, but they cannot be the only causes of acid soils. A 1934 study (reconfirmed by a 1968 study) concluded that soils in dry regions tend to be neutral or alkaline while humid areas have acidic soils as the result of natural processes. R. Patrick mentioned in *Science* earlier this year that "naturally acid lakes and ponds have existed since the 1860s in New England and New Jersey, and similar shallow lakes and ponds occur also in the Southeast."